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# RELATION BETWEEN CSR FUNCTIONAL SIGNATURES OF DRY GRASSLANDS FROM TWO CONTRASTING GEOLOGICAL SUBSTRATES

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## *ABSTRACT*

*The paper presents floristic and functional comparison of two adjacent and structurally similar plant communities – calcareous* (Bromion erecti) *and silicicolous* (Nardo-Agrostion tenuis) *dry grasslands. For functional comparison Grime's CSR triangle theory of plant strategies was used. The analysis of species composition showed great differences between both dry grassland types. Higher relative proportions of S component and lower relative proportions of C components in silicicolous grasslands suggest that those habitats generally experience higher intensities of stress when compared to calcareous grasslands, presumably owing to low resource availability on high-acidic sites and also due to their occurrence in higher altitudes.*

**Key words:** calcareous dry grasslands, silicicolous dry grasslands, species composition, plant functional types, plant traits, Slovenia

# RELAZIONE TRA SIGLE FUNZIONALI CSR DI PASCOLI ARIDI SU DUE SUBSTRATI GEOLOGICI CONTRASTANTI

*SINTESI*

*L'articolo presenta la comparazione floristica e funzionale fra due comunità vegetali adiacenti e strutturalmente simili – calcarea* (Bromion erecti) *e silicea* (Nardo-Agrostion tenuis) *di pascoli aridi. Per la comparazione funzionale è stato usato il modello CSR di Grime, inerente alle strategie ecologiche delle piante. L'analisi della composizione delle specie ha evidenziato notevoli differenze fra i due tipi di pascoli aridi. Maggiori proporzioni relative della componente S e minori proporzioni della componente C nei pascoli aridi silicei suggeriscono che tali habitat generalmente sono sottoposti a maggiori intensità di stress in confronto ai pascoli aridi calcarei. Tale risultato presumibilmente è collegato alla minore disponibilità di risorse in siti ad alta acidità e al fatto che tali pascoli si trovano ad altitudini elevate.*

**Parole chiave:** pascoli aridi calcarei, pascoli aridi silicei, composizione di specie, tipi funzionali vegetali, caratteristiche morfologiche vegetali, Slovenia

## INTRODUCTION

The traditional approach to vegetation classification is taxonomic in nature and usually performed at the species level (Duckworth *et al.*, 2000). On a large scale, predictions based on plant species are geographically bound (Woodward & Cramer, 1996). On a small scale, species are in some cases so widely spread and variable that by describing communities by species composition we may not perceive relevant patterns occurring below the resolving power of species (Diaz *et al.,* 1992). Consequently, classifying plant species according to their higher taxonomical level has strong limitations when it comes to answering important ecological questions at the scale of ecosystems, landscapes or biomes (Keddy, 1992; Körner, 1993). A promising way for answering such questions, as well as various other ecological questions, is by classifying plant species by their shared biological characteristics that relate to function, rather than by phylogeny (Grime *et al.*, 1988; Lavorel *et al.*, 1997; Diaz *et al.*, 2002). These alternative classes are often referred to as plant functional types or groups (Leishman & Westoby, 1992; Grime *et al.*, 1988; Gitay & Noble, 1997). Plant functional types can be defined as groups of plant species sharing similar functioning at the organismic level, similar responses to environmental factors (*e.g.,* temperature, water availability, nutrients, fire and grazing), and/or similar roles in (or effects on) ecosystems or biomes (*e.g.,* productivity, nutrient cycling, flammability and resilience) (Walker, 1992; Chapin *et al.*, 1996; Nobble & Gitay, 1996; Diaz & Cabido, 1997; Lavorel *et al.*, 1997; Grime, 2001). With plant functional types, comparisons between communities of widely differing composition can be facilitated (Diaz *et al.,* 2004).

The underlying bases for schemes of plant functional types can vary widely (Ramenskiy, 1938; Hermy & Stieperaere, 1985; Grime, 2001). One of three-type schemes, the so-called "CSR plant strategy theory" (Grime, 1974, 1977, 1979, 2001) is particularly efficient in the balance between the power of its predictions and the simplicity of its assumptions (Hunt *et al.*, 2004). Grime (1974, 1977, 1979, 2001) developed a classification based on how plants deal with two groups of external environmental factors, stress and disturbance. This scheme results in three primary plant strategies: competitors (C), stress-tolerators (S), and ruderals (R) and several intermediate strategies. The position of any species can be displayed upon a triangular ordination diagram (Grime, 1974, 2001; Hodgson *et al.*, 1999). Each strategy is characterized by a distinct set of ecological, morphological and physiological traits and is found in species occupying habitats of a particular kind (Grime *et al.*, 1988). Hodgson *et al.* (1999) developed a methodology that classifies unknown herbaceous subject based on validated "soft" traits (*i.e.* relatively undemanding), allowing practical ordination of wild plants within CSR space. The position in CSR diagram can be determined also for an entire vegetation sample (relevé). Hunt *et al.* (2004) presented a quantitative tool which facilitates the reduction of herbaceous plant communities to collections of functional types. The whole community is given a "functional signature", a three-part numerical index which concisely represents the balance between the different functional attributes that are present among the component species (Hunt *et al.*, 2004). The integrative power of the CSR signature is useful in comparative studies involving widely differing samples (Hunt *et al.*, 2004). Although Grime's CSR triangle theory has been often criticized (Tilman, 1988; Silvertown *et al.*, 1992; Wilson & Lee, 2000), Grime's ideas remain fundamental to the development of functional classifications and functional interpretation of plant communities (Hills *et al.,* 1994; Caccianiga *et al.*, 2006; Pipenbaher *et al.*, 2008; Zelnik & Čarni, 2008).

The aim of the present study was to determine whether two contrasting geological substrates – calcareous and silicicolous, affect the CSR functional signatures of related grasslands, being floristically substantially distinct. We actually compared species composition and plant life strategies as defined by Grime (1974) of two adjacent and structurally-similar plant communities on acidic and calcareous soils from the central part of Slovenia – acidic Matgrass (*Nardus stricta*) grasslands and species-rich calcareous grasslands. We applied the method of Hodgson *et al.* (1999) to allocate CSR plant functional types and the approach of Hunt *et al.* (2004) to derive a functional signature for the researched grasslands communities. These vegetation types were created by traditional, infrequent low intensity grazing or mowing with no external inputs (fertilizers) in the past (Škornik, 2003; Kaligarič *et al.*, 2006). They represent grasslands of moderate productivity and despite contrasting geological substrates both vegetation types represent habitats subject to a similar combination of intermediate level of disturbance and stress due to nutrient poor and shallow rocky soils which experience desiccation during the summer. We hypothesized that despite wide differences in plant species composition there are no significant differences in functional signatures between calcareous and silicicolous grassland types with respect to C, S and R components, since they both represent habitats experiencing nearly comparable effects of climate and land-use.

## MATERIALS AND METHODS

### Study area

The studied calcareous semi-dry grasslands appear only in small fragments in the hilly region of pre-Alpine and pre-Pannonian region and on low Dinaric and pre-

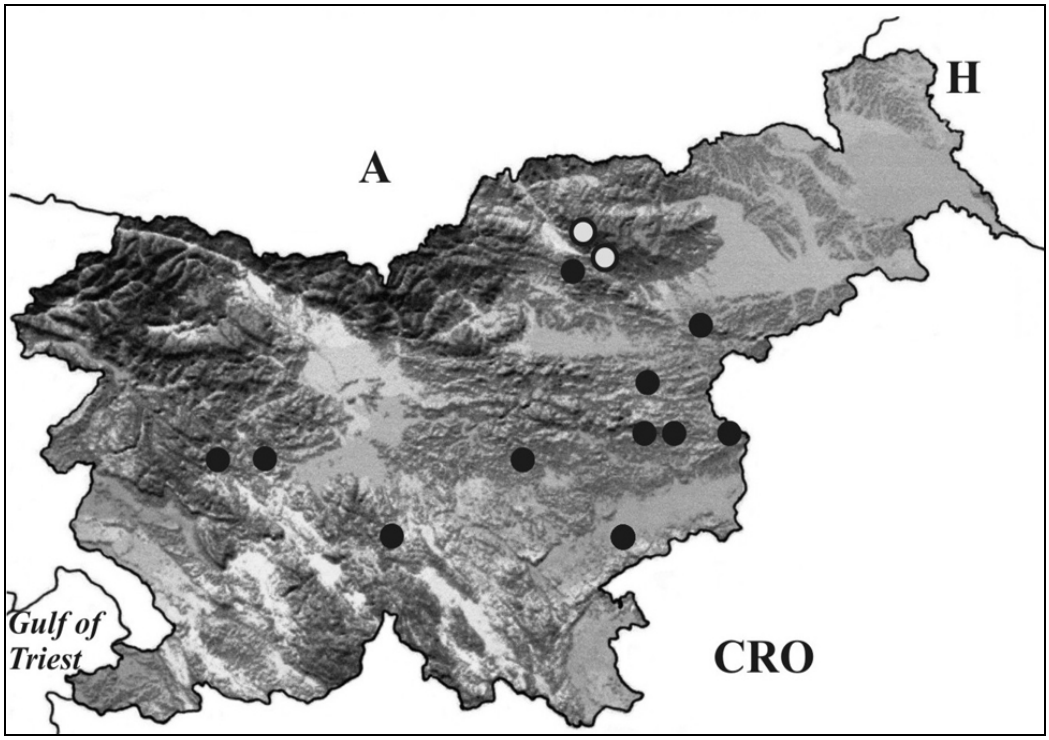


***Fig. 1: Map of Slovenia with locations of the collected relevés of calcareous (●) and silicicolous (O) dry grasslands.***
***Sl. 1: Karta Slovenije z lokalitetami popisov suhih travnikov na apnencih (●) in silikatih (O).***

Dinaric karst plateau at ca. 500-1100 m a.s.l. (Fig. 1). The geological substrate is made of calcareous limestone and dolomite. The climate is continental with mild to hot summers and cold winters. Mean annual temperature is between 6 and 10.5°C. The average annual precipitation is between 1000 and 1300 mm. The relevés of studied calcareous semi-dry grasslands belong to species-rich meadows from the *Bromion erecti* alliance described as association *Scabioso hladnikianae-Caricetum humilis* (Škornik, 2001). These grasslands are distributed over exposed sunny and dry areas and are therefore rich in xero-thermophilous and basiphilous species.

The silicicolous Matgrass grasslands were studied on the summit areas of Pohorje Mountains (NE Slovenia) (Fig. 1) at altitudes at ca. 1500 m a.s.l. We analysed relevés of association *Homogyno alpinae-Nardetum* (alliance *Nardo-Agrostion tenuis*, order *Nardetalia*) (Kaligarič & Škornik, 2002). Pohorje, the most dominant mountain range in the NE Slovenia, is situated at the south-easternmost edge of the Central (non-carbonate) Alps. The main characteristic of these grasslands are acid soils (pH less than 4.0), the result of the non-carbonate geological bedrock, predominantly metamorphic rocks and granodhiorythic lacolith (Hinterlechner-Ravnik, 1995). The study area has the montane climate with fresh summers and cold winters. The average temperature in the coldest month is below –3°C and in the warmest month above 10°C. The average annual precipitation is approx. 1336 mm (Ribniška koča, 1530m) (Furlan, 1980). These grasslands occur mainly on flat plains and gentle sloping ridges with very dry and shallow soils, poor with minerals and with low pH values (Kaligarič & Škornik, 2002). They are rich in species designated as xerophilous and acidophilous species.

### Vegetation survey

We analysed 30 relevés of dry grasslands on calcareous bedrock – association *Scabioso hladnikianae-Caricetum humilis* (Škornik, 2001) and 32 vegetation relevés of dry grasslands on silicicolous bedrock – association *Homogyno alpinae-Nardetum* (Kaligarič & Škornik, 2002). Relevés were collected using standard procedure of the sigmatistic method (Braun-Blanquet, 1964; Westhoff & van der Maarel, 1973; Dierschke, 1994).

### Allocating a CSR plant functional type to plant species and vegetation samples (relevés)

The CSR scheme takes into account a number of different plant traits (Hodgson *et al.*, 1999). To determine one of 19 CSR functional types for 122 plant species recorded in 62 analysed vegetation relevés we used a rapid method for attribution of CSR type from simple measurements and data published by Hodgson *et al.* (1999). We used the following plant traits: canopy

height, leaf dry matter content, flowering period, flowering start, lateral spread, leaf dry weight, specific leaf area. Traits were chosen from our own database (protocol standardized by Cornelissen *et al.*, 2003). Calculations of CSR coordinates were made by entering these data into the spreadsheets of Hodgson *et al.* (1999), made available for this purpose at www.ex.ac.uk/~rh203/allocating_csr.html. For 21 plant species we used data from a look-up table with CSR types for 1000 European species (source J. G. Hodgson, UCPE Sheffield).

The relative proportions of CSR functional types for our 62 samples (relevés) of vegetation were calculated and plotted in CSR triangle by using spreadsheet-based tools of Hunt *et al.* (2004), available at www.people.exeter.ac.uk/rh203/allocating_csr.html.

To test differences in relative proportions of C-, S- and R-strategists among relevés of calcareous and silicicolous dry grasslands, we used a *Student's* t-test for independent samples (SPSS Inc., 2006), since the data were sufficiently normally distributed (Shapiro-Wilks and Lilliefors tests).

### Nomenclature

Taxonomic nomenclature follows Martinčič *et al.* (2007), syntaxonomic nomenclature follows Mucina *et al.* (1993), Grabherr & Mucina (1993) and Škornik (2003).

## RESULTS

The total number of vascular plant species recorded in 62 relevés of studied grassland communities was 143 with 105 in the calcareous (mean=45±6.8 per plot, N=30) and 45 (mean=16±3.8 per plot, N=32) in the silicicolous grasslands. There are only 7 common species, namely *Antennaria dioica, Anthoxanthum odoratum, Cruciata glabra, Gymnadenia conopsea, Luzula campestris, Potentilla erecta* and *Veronica chamaedrys*, 98 exclusive to the calcareous and 38 exclusive to the silicicolous semi-dry grasslands. All species are listed in Appendix 1.

Characteristic of calcareous semi-dry grasslands are particularly many calciphilous and xerophilous species, such as *Acinos alpinus, Anthericum ramosum, Bromopsis erecta, Centaurea scabiosa* subsp. *fritschii, Globularia punctata, Helianthemum ovatum* and *Koeleria pyramidata*, which are absent on non-carbonate soil. In silicicolous grasslands calcifuge species which can tolerate soil with lower pH values appear, such as *Arnica montana, Calluna vulgaris, Carex pilulifera, Festuca rubra, Hieracium pilosella, Nardus stricta* and *Ranunculus acris*.

Ordination of species within CSR space (Tab. 1) demonstrate that CR, SC, CSR and the combination of SC and CSR types are prevalent strategies of plant species on both calcareous and silicicolous semi-dry grasslands. The most frequent are competitive-ruderals (CR), which were especially strongly represented in the species composition of silicicolous semi-dry grasslands (33.34%). Examples of competitive-ruderals are species *Agrostis capillaris, Carlina acaulis, Cirsium pannonicum, Linum catharticum, Plantago media, Rhinanthus glacialis* and *Stellaria graminea*. Stress-tolerant competitors (SC) included some grasses, sedges and rushes, *e.g. Carex flacca, Deschampsia caespitosa, Luzula luzuloides* and *Molinia caerulea*. CSR strategists include small geophytes (*e.g. Orchis tridentata, Orchis ustulata* and *Primula veris*), small deep-rooted forbs with rosettes (*e.g. Antennaria dioica, Plantago lanceolata, Scabiosa columbaria, Silene vulgaris*) and small sedges like *Carex ornithopoda* (Append. 1).

***Tab. 1: CSR strategies of 143 plant species recorded in 62 relevés of dry grasslands from calcareous (30 relevés) and silicicolous (32 relevés) geological substrates. Values are percentage frequencies.***
***Tab. 1: CSR strategije 143 rastlinskih vrst suhih travnikov na karbonatni (30 popisov) in silikatni (32 popisov) geološki podlagi. Vrednosti v tabeli ustrezajo frekvencam (%) pojavljanja vrst.***

| | Calcareous | Silicicolous |
|---|---|---|
| N of relevés | 30 | 32 |
| N of plant species | 105 | 45 |
| **CSR plant strategy** | | |
| C | 2.9 | 0.0 |
| S | 1.0 | 0.0 |
| R | 0.0 | 0.0 |
| **CR** | **19.1** | **33.3** |
| SR | 1.0 | 0.0 |
| **SC** | **17.1** | **11.1** |
| **CSR** | **17.1** | **8.9** |
| C/CR | 4.8 | 2.2 |
| C/SC | 3.8 | 2.2 |
| C/CSR | 3.8 | 0.0 |
| CR/CSR | 1.9 | 4.4 |
| R/CR | 2.9 | 4.4 |
| R/CSR | 0.0 | 0.0 |
| R/SR | 1.0 | 0.0 |
| SR/CSR | 4.8 | 2.2 |
| **SC/CSR** | 5.7 | **15.6** |
| S/SC | 5.7 | 6.7 |
| S/CSR | 5.7 | 6.7 |
| S/SR | 1.9 | 2.2 |

The positions of calculated functional signatures for all 62 relevés of studied grasslands in CSR space are presented in Figure 2. Relevés are arranged on the right side of the triangle along the line, where stress and competition in various equilibria are the most important determinants of the vegetation.

When calculating functional signatures, we considered the percentage of abundance of each plant species in relevé. Differences in functional signatures within the samples (relevés) of both vegetation types are due to fluctuations in abundance of dominant species which can be linked to differences in soil characteristics of microhabitat or to disturbance abundance (Fig. 2). Relevés of calcareous grassland positioned in the upper part of the triangle represent less-managed grasslands that exhibit conditions favourable to the species with stressed C component, such as *Brachypodium pinnatum, Centaurea scabiosa* subsp. *fritschii* and *Peucedanum oreoselinum.* The relative importance of S-coordinate in the part of relevés of silicicolous grasslands was revealed due to the strong dominance of stress-tolerant grass species *Nardus stricta* in those vegetation samples.

The comparison of relative proportions of C, S and R components among relevés showed significantly (P <0.0001) higher relative proportions of S component (mean=0.52, N=32) in silicicolous grasslands than in calcareous grasslands (mean=0.37, N=30). On the other hand, calcareous grasslands had significantly (P <0.0001) higher relative proportions of C component (mean=0.46, N=30) than acid grasslands (mean=0.31, N=32).

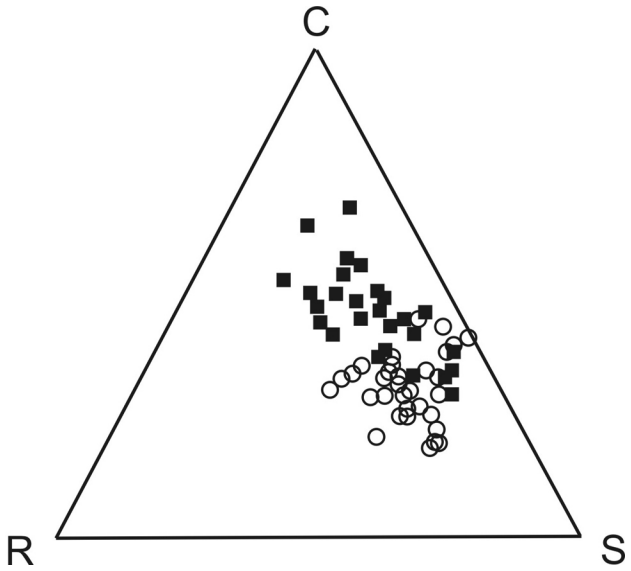


***Fig. 2: CSR ordination of relevés (N=62, 143 species) of dry grasslands from calcareous and silicicolous geological substrates. Legend: ■ – calcareous dry grasslands; O – silicicolous dry grasslands.***
***Sl. 2: CSR ordinacija popisov (N=62, 143 vrst) suhih travnikov na karbonatni in silikatni geološki podlagi. Legenda: ■ – popisi karbonatnih suhih travnikov ; O – popisi silikatnih suhih travnikov.***

## DISCUSSION

As expected and observed for a long time (*e.g.,* Gigon, 1987, Grime, 1979; Pärtel, 2002), great floristic differences between the calcareous and non-calcareous (silicolous) grasslands were found. These habitats have only a few common species and many species related to either basic or acidic soil pH. It is generally accepted that the main reason why some substrates host different plant species than others lies in chemical processes and factors rather than in physical ones (temperature, moisture, etc.) (Kinzel, 1983; Gigon, 1987).

The calcareous grasslands are characterized by high species richness, typical of these semi-natural grasslands (*Bromion erecti*) in extensive use, which are among the most species-rich habitats in Europe (Willems *et al.*, 1993). Pärtel (2002) and Ewald (2003) suggest that the relationship between local species density and soil pH is determined by regional species pool size (Zobel *et al.*, 1998), which in turn reflects the relative abundance of soil types during the evolutionary history of the flora. Ewald (2003) observed that calcareous sites in Central Europe have higher species density and larger species pool than acidic sites, and argues that this is due to a Pleistocene bottleneck for acidophiles. Peet *et al.* (2003) contradict the assertion of Pärtel (2002) and Ewald (2003). They conclude that richness on higher pH sites is a result of generally more favorable conditions for plant growth and/or establishment. It is known that more base-rich sites are generally more invasible *(e.g.*, Davis *et al.*, 2000; Brown & Peet, 2003), presumably owing to greater resource availability on high-base sites. Under extreme acidity, the nutrient cations are so mobile that they are easily leached into groundwater (Gurevitch *et al.*, 2002).

CSR classification of all species recorded (Tab. 1) expresses the response on stress and disturbance in the studied grasslands. The three primary C-, S-, and R-strategists represent extremes in the range of conditions available to plants (Grime, 2001) and are therefore very rare in grasslands we have researched. Namely, these are habitats experiencing intermediate intensities of stress and disturbance and in such circumstances the vegetation usually includes many species with strategies intermediate between those of the competitor, the stress-tolerator, and the ruderal (Grime, 2001). For the investigated unfertilised dry grasslands, effect of disturbance is mainly due to the mowing once a year (or even every second year) and occasional grazing (Kaligarič & Škornik, 2002; Škornik *et al.*, 2006). Although these disturbances are severe, they occur infrequently and prevent dominance by competitors. The competitive nature of

species in the present study is restricted also by moderate stress conditions, due to nutrient-deficient and shallow soils which experience desiccation during summer. Many species within competitive-ruderals and stress-tolerant competitors *(e.g. Agrostis capillaries, Carex flacca, Deschampsia caespitosa, Molinia caerulea)* are perennials showing capacity for rapid lateral vegetative spread and for efficient colonisation of temporary gaps (Lovett-Doust, 1981).

According to Hunt *et al.* (2004), the integrative power of the functional signatures within the context of the CSR system of plant functional types is especially useful in comparative studies of widely differing samples. We hypothesized that despite very different floristic composition there will be no significant differences in functional signatures between relevés of silicicolous and calcareous dry grasslands. Our results do not support our hypotheses, however, they agree with the observations that more base-rich sites are less stressful for plants. We can observe some relevés, which showed similar values of functional signatures (Fig. 2). These were samples of calcareous grasslands characterised by severe level of stress due to extremely shallow dry soil and less-managed or even unmanaged samples of silicicolous dry grasslands. Species which were abundant in these habitats were stress-tolerant competitors (SC, S/SC). Examples are *Carex humilis, Koeleria pyramidata, Leontodon incanus, Hippocrepis comosa* and *Dianthus carthusianorum,* all species which were abundant in calcareous grasslands. The predominant stress-tolerant competitors in the case of overlapping acidic dry grasslands were members of the Ericaceae: *Calluna vulgaris*, *Vaccinium myrtillus* and *V. vitis-idaea*. In Europe and North America these sclerophyllous shrubs species are very common and associated with nutrient-deficient acidic soils if management regimes allow the development of woody vegetation (Grime, 2001). Beside the soil chemistry, the altitudinal distribution of sample grasslands should not be neglected as well; the silicicolous grasslands were sampled in higher altitudes, where growing period is shorter and climatic conditions are sharper. These require plant strategies closer to S strategy, which was actually confirmed within the present study.

In conclusion, although some authors have expressed doubts concerning the predictive power of CSR theory (Wilson & Lee, 2000), we have demonstrated its usefulness in comparative analysis of plant communities of widely differing species composition.

# PRIMERJAVA CSR FUNKCIONALNIH OZNAK SUHIH TRAVIŠČ Z DVEH RAZLIČNIH GEOLOŠKIH PODLAG

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*POVZETEK*

*Z našo študijo smo želeli odgovoriti na vprašanje, ali različna podlaga – karbonatna in ne-karbonatna silikatna vpliva na razlike v CSR funkcionalni oznaki dveh po strukturi podobnih rastlinskih združb. Za funkcionalno primerjavo smo uporabili Grime-ov model CSR ekoloških strategij rastlin. Proučevani suhi travniki predstavljajo antropogeni habitat, ki je nastal kot posledica dolgotrajne tradicionalne ekstenzivne paše oz. košnje. To so travišča z zmerno produkcijo, ki so kljub kontrastni geološki podlagi podvržena primerljivi kombinaciji zmerne motnje ter stresa. Slednji je predvsem posledica pomanjkanja hranil v tleh ter vodnega stresa zaradi plitkih kamnitih tal, ki se v poletnih mesecih pogosto izsušijo. Tako smo postavili hipotezo, da kljub zelo različni floristični sestavi ne bomo našli statistično značilnih razlik v funkcionalnih oznakah za oba tipa vegetacije. Analizirali smo 30 fitocenoloških popisov suhih travnikov na karbonatih (asoc.* Scabioso hladnikianae-Caricetum humilis*, zveza* Bromion erecti*) ter 32 fitocenoloških popisov silikatnih suhih travnikov (asoc.* Homogyno alpinae-Nardetum*, zveza* Nardo-Agrostion tenuis*). Na osnovi primerjave floristične sestave smo potrdili, da se suhi travniki na karbonatni in silikatni geološki podlagi med sabo*

*zelo razlikujejo, saj se od zabeleženih skupno 142 vrst, samo 7 rastlinskih vrst pojavlja tako na silikatnih kot tudi na karbonatnih travnikih. Primerjavo tipov CSR ekoloških strategij smo izvedli na osnovi frekvenc (v %) pojavljanja vrst v skupinah popisov. Pokazala je, da je sestava CSR tipov ekoloških strategij na obeh tipih suhih travnikov zelo podobna. Na obeh traviščih prevladujejo vrste s t.i. sekundarnimi CSR ekološkimi strategijami C-R, C-S in CSR, značilne za vrste podvržene zmernemu stresu in motnji. Pri izračunavanju funkcionalih oznak popisov upoštevamo ne samo prisotnost/odsotnost temveč tudi pokrovnost vrst v popisih. Primerjava razporeditve funkcionalnih oznak popisov v CSR trikotniku je tako pokazala, da imata na proučevana suha travišča najpomembnejši vpliv stres in kompeticija v različnih razmerjih. Razlike v funkcionalnih oznakah med popisi znotraj posameznega tipa suhih travnikov se pojavljajo zaradi nihanja v pogostnosti dominantnih vrst, ki so posledica razlik v talnih razmerah ter stopnjah motnje. Kljub temu, da so si funkcionalne oznake nekaterih popisov iz različnih geoloških podlag zelo podobne, pa so statistične analize pokazale statistično značilne večje relativne deleže komponente S in manjše relativne deleže komponente C v popisih silikatnih travnikov. Naši rezultati tako ne podpirajo naše hipoteze, v kateri smo predvideli, da ne bomo našli statistično značilnih razlik v funkcionalnih oznakah za oba tipa vegetacije. Zato pa lahko naše izsledke uporabimo za potrditev domneve o bolj stresnih razmerah na rastiščih z nižjimi pH vrednostmi tal. Ta domneva namreč predstavlja enega izmed najpogostejših odgovorov, ki ga različni raziskovalci ponujajo na zelo znano vprašanje v ekologiji rastlin, zakaj obstaja toliko večja vrstna pestrost na tleh z višjimi vrednostmi pH v primerjavi s tlemi z nižjimi pH vrednostmi.*

**Ključne besede:** karbonatni suhi travniki, silikatni suhi travniki, vrstna sestava, funkcionalni tipi rastlin, morfološke poteze rastlin, Slovenija

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***Appendix 1: A list of 143 plant species recorded in 62 relevés of dry grasslands from calcareous (30 relevés) and silicicolous (32 relevés) geological substrates. Species values are percentage frequencies.***
***(*) Data from look-up table with CSR types for 1000 European species (source J. G. Hodgson, UCPE Sheffield).***
***Priloga 1: Seznam 143 rastlinskih vrst zabeleženih v 62 popisih suhih travišč na apnenčasti (30 popisov) in silikatni (32 popisov) geološki podlagi. Vrednosti ustrezajo frekvencam pojavljanja vrst v skupinah popisov***
***(*) Podatki, ki smo jih povzeli iz tabele s CSR tipi za 1000 vrst Evropske flore (vir J. G. Hodgson, UCPE Sheffield).***

| Species | CSR plant strategy | Calcareous | Silicicolous |
|---|---|---|---|
| | | | |
| *Acinos alpinus* | CSR* | 70 | . |
| *Agrostis capillaris* | CR | . | 9 |
| *Anacamptis pyramidalis* | R/CR | 20 | . |
| *Anemone nemorosa* | C/SC | . | 19 |
| *Antennaria dioica* | CSR* | 17 | 25 |
| *Anthericum ramosum* | C/CR | 57 | . |
| *Anthoxanthum odoratum* | SR/CSR | 20 | 16 |
| *Anthyllis vulneraria* | CR | 80 | . |
| *Arnica montana* | CR | . | 97 |
| *Arrhenatherum elatius* | C/CSR | 13 | . |
| *Asperula cynanchica* | SR/CSR | 63 | . |
| *Avenella flexuosa* | SC/CSR | . | 63 |
| *Avenochloa pubescens* | CR | 13 | . |
| *Betonica officinalis* | C/CR | 13 | . |
| *Brachypodium rupestre* | C | 100 | . |
| *Briza media* | SC/CSR | 80 | . |
| *Bromopsis erecta* agg. | C/CSR | 83 | . |
| *Buphthalmum salicifolium* | CR | 93 | . |
| *Calluna vulgaris* | SC | . | 78 |
| *Campanula barbata* | CR | . | 75 |
| *Carex caryophyllea* | S | 87 | . |
| *Carex flacca* | SC | 60 | . |
| *Carex humilis* | S/SC | 50 | . |
| *Carex montana* | S/SC | 70 | . |
| *Carex ornithopoda* | CSR* | 27 | . |
| *Carex pilulifera* | SC/CSR | . | 34 |
| *Carlina acaulis* | CR | 67 | . |
| *Carlina vulgaris* | CR | 13 | . |
| *Centaurea pannonica* | CR | 10 | . |
| *Centaurea jacea* subsp. *jacea* | SC/CSR | 30 | . |
| *Centaurea scabiosa* subsp. *fritschii* | C/CR | 90 | . |
| *Centaurea triumfettii* | CR | 20 | . |

| Species | CSR plant strategy | Calcareous | Silicicolous |
|---|---|---|---|
| | | | |
| *Chamaecytisus supinus* | SC/CSR | 33 | . |
| *Chamaespartium sagittale* | S/CSR | 10 | . |
| *Cirsium pannonicum* | CR | 70 | . |
| *Cruciata glabra* | S/SC | 23 | 13 |
| *Dactylis glomerata* | C/CSR | 50 | |
| *Deschampsia caespitosa* | SC | . | 16 |
| *Dianthus carthusianorum* | SC | 63 | . |
| *Dorycnium germanicum* | CR/CSR | 17 | . |
| *Euphorbia cyparissias* | CSR | 60 | . |
| *Euphorbia verrucosa* | S/SC | 63 | . |
| *Euphrasia stricta* | CR/CSR | . | 6 |
| *Festuca rubra* agg. | CSR | . | 50 |
| *Festuca rupicola* | S/CSR | 87 | . |
| *Galium mollugo* | C/CSR | 13 | . |
| *Galium verum* | SC/CSR | 40 | . |
| *Genista januensis* | CS* | 77 | . |
| *Gentiana cruciata* | CR | . | 19 |
| *Gentiana pannonica* | CR | . | 22 |
| *Gentiana utriculosa* | SR/CSR | 20 | . |
| *Gentiana verna* subsp. *tergestina* | SC | 20 | . |
| *Gentianella germanica* | CSR* | 20 | . |
| *Geranium sanguineum* | C/SC | 33 | . |
| *Globularia cordifolia* | SC | 10 | . |
| *Globularia punctata* | C/SC | 80 | . |
| *Gymnadenia conopsea* | S/SR* | 40 | 44 |
| *Helianthemum ovatum* | SR/CSR | 93 | . |
| *Hieracium aurantiacum* | CR | . | 28 |
| *Hieracium bauhinii* | C/CR | 30 | . |
| *Hieracium laeviculae* | CR | . | 41 |
| *Hieracium pilosella* | SC | 17 | . |
| *Hippocrepis comosa* | SC | 73 | . |
| *Homogyne alpina* | CR | . | 47 |
| *Hypericum montanum* | SC/CSR | . | 6 |
| *Hypericum perforatum* | SC | . | 13 |
| *Hypochoeris maculata* | C/CR | 53 | . |
| *Hypochoeris uniflora* | CR | . | 25 |
| *Inula salicina* | CS* | 17 | . |
| *Knautia drymeia* | CR | 50 | . |
| *Koeleria pyramidata* | S/SC | 100 | . |
| *Laserpitium siler* | C/SC | 23 | . |
| *Leontodon helveticus* | R/CR | . | 47 |
| *Leontodon hispidus* subsp. *danubialis* | CR | 37 | . |
| *Leontodon incanus* | SC | 73 | . |
| *Leucanthemum vulgare* | C* | 40 | . |
| *Leucanthemum ircutianum* | CR | . | 9 |
| *Lilium martagon* | CSR* | 10 | . |
| *Linum catharticum* | CR | 67 | . |
| *Linum viscosum* | CS* | 10 | . |
| *Lotus corniculatus* | SC/CSR | 77 | . |
| *Luzula campestris* | S/CSR | 17 | 41 |

| Species | CSR plant strategy | Calcareous | Silicicolous |
|---|---|---|---|
| | | | |
| *Luzula luzuloides* | SC | . | 41 |
| *Luzula pilosa* | SC/CSR | . | 44 |
| *Luzula sylvatica* | SC/CSR | . | 38 |
| *Lychnis flos-cuculi* | CR | . | 38 |
| *Medicago lupulina* | R/SR | 17 | |
| *Melampyrum pratense* | CR/CSR | . | 75 |
| *Molinia caerulea* | SC | . | 6 |
| *Nardus stricta* | S/CSR | . | 100 |
| *Orchis morio* | S/SR | 13 | . |
| *Orchis tridentata* | CSR* | 33 | . |
| *Orchis ustulata* | CSR* | 23 | . |
| *Peucedanum cervaria* | C | 10 | . |
| *Peucedanum oreoselinum* | C/SC | 83 | . |
| *Phyteuma orbiculare* | SC | 30 | . |
| *Phyteuma spicatum* | C/CR | . | 6 |
| *Pimpinella saxifraga* | CR | 47 | . |
| *Plantago lanceolata* | CSR | 83 | . |
| *Plantago media* | CR | 90 | . |
| *Platanthera bifolia* | R/CR | 10 | . |
| *Polygala chamaebuxus* | CS* | 23 | . |
| *Polygala comosa* | S/SC | 90 | . |
| *Polygala vulgaris* | SC/CSR | 13 | 6 |
| *Polygonatum odoratum* | CR | 13 | . |
| *Potentilla erecta* | S/CSR | 27 | 100 |
| *Primula vulgaris* | CSR* | 33 | . |
| *Prunella grandiflora* | CR/CSR | 43 | . |
| *Prunella laciniata* | CR | 27 | . |
| *Prunella vulgaris* | R/CR | 17 | . |
| *Pseudorchis albida* | R/CR | . | 13 |
| *Pulsatilla grandis* | CSR* | 10 | . |
| *Ranunculus acris* | CSR | . | 9 |
| *Ranunculus bulbosus* | SR | 43 | . |
| *Ranunculus nemorosus* | CR | 33 | . |
| *Rhinanthus glacialis* | CR | 57 | . |
| *Rhinanthus minor* | SR/CSR | 10 | . |
| *Rhinanthus pulcher* | CR | . | 6 |
| *Salvia pratensis* | CR | 50 | . |
| *Sanguisorba minor* | SC | 97 | . |
| *Scabiosa columbaria* | CSR* | 17 | . |
| *Scabiosa hladnikiana* | CR | 53 | . |
| *Scabiosa triandra* | CR | 63 | . |
| *Silene nutans* | S/CSR | 40 | . |
| *Silene vulgaris* | CSR* | 20 | . |
| *Solidago virgaurea* | CR | . | 59 |
| *Stachys recta* | SC | 37 | . |
| *Stellaria graminea* | CR | . | 6 |
| *Teucrium chamaedrys* | SC/CSR | . | 6 |
| *Thalictrum minus* | S/CSR | 13 | . |
| *Thesium bavarum* | CSR* | 60 | . |

| Species | CSR plant strategy | Calcareous | Silicicolous |
|---|---|---|---|
| | | | |
| *Thlaspi praecox* | SC | 33 | . |
| *Thymus pulegioides* | SC/CSR | 60 | . |
| *Tofieldia calyculata* | CS* | 13 | . |
| *Trifolium montanum* | SC | 83 | . |
| *Trifolium pratense* | CSR | 17 | . |
| *Vaccinium myrtillus* | S/SC | . | 66 |
| *Vaccinium vitis-idaea* | S/SC | . | 69 |
| *Veratrum album* subsp. *album* | CR | . | 50 |
| *Veronica chamaedrys* | CSR | 10 | 6 |
| *Veronica jacquinii* | SC | 63 | . |
| *Viola canina* | CSR* | 13 | . |

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# ELEVATIONAL DISTRIBUTION OF SMALL TERRESTRIAL MAMMALS ON MT. POHORJE, SLOVENIA

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## *ABSTRACT*

*Small mammals were sampled on Mt. Pohorje at 33 localities, ranging in elevation from 250–300 m to 1530 m a.s.l. Species composition varied, depending on the method employed during field surveys. Snap trapping was more effective in sampling rodents while pitfall trapping provided more shrews. Twenty-two species were identified, but commensal* Rattus rattus *and* Mus musculus *were excluded from further analyses. Fourteen species of a total 20 occurred all along the elevational gradient and the overall turnover rate was excessively low (β = 0.17). The overall elevational pattern in species richness on Mt. Pohorje was thus a steady decline in species numbers along the altitudinal gradient. Relative abundance of mice (Muridae) declined with increasing elevation (r = -0.844) while shrews (Soricidae) were becoming more abundant in the same direction (r = 0.839).*

**Key words:** Alps, Pohorje, elevational extent, mid-domain model, small mammals, species richness

# DISTRIBUZIONE ALTITUDINALE DI PICCOLI MAMMIFERI TERRESTRI SUL MONTE POHORJE, SLOVENIA

*SINTESI*

*I piccoli mammiferi sono stati campionati in 33 località del monte Pohorje, ad un'altitudine compresa fra i 250–300 m ed i 1530 m s.l.m. La composizione delle specie era variabile, in relazione al metodo impiegato durante il campionamento. Le trappole a scatto si sono rivelate più efficienti nel campionamento dei roditori, mentre le trappole coperte catturavano più toporagni. Ventidue specie sono state identificate, ma i commensali* Rattus rattus *e* Mus musculus *sono stati esclusi da successive analisi. Quattordici specie delle venti totali sono state trovate lungo tutto il gradiente altitudinale, mentre il ricambio globale di specie è risultato molto basso (β = 0,17). Il modello altitudinale completo in ricchezza di specie sul monte Pohorje ha pertanto evidenziato un regolare declino nella ricchezza di specie lungo il gradiente altitudinale. L'abbondanza relativa dei topi (Muridae) è diminuita con l'aumentare dell'altitudine (r = -0,844), mentre i toporagni (Soricidae) sono risultati più abbondanti nella stessa direzione (r = 0,839).*

**Parole chiave:** Alpi, Pohorje, estensione altitudinale, modello di medio-dominio, piccoli mammiferi, ricchezza di specie

## INTRODUCTION

Naturalists have been aware for centuries that species are not evenly distributed on the Earth's surface (Brown & Lomolino, 1998). The distribution of organisms is not random and few patterns of species richness are seemingly universal across time, geographical scale, and taxa (Rahbek, 1997). The oldest and one of the most fundamental patterns is the decrease in biological diversity from equatorial to polar regions and is known as latitudinal gradient (Willig *et al.*, 2003). A similar pattern of species decline along the elevational gradient was long believed to mirror the latitudinal gradient and to be a general pattern in mountain biotas (Stevens, 1992). Such a perception, derived primarily from tropical regions, claimed axiomatically that lowlands support the highest number of species (MacArthur, 1972). As shown subsequently, the relationship between species richness and elevation rather shows three basic patterns: a humped-shaped curve, a monotonic decrease, or almost horizontal species richness curve that declines at certain elevation (Rahbek, 1995). A series of recent papers based on small mammal distributions across continents (Heaney, 2001; Lomolino, 2001; Nor, 2001; Rickart, 2001; Sánchez-Cordero, 2001; McCain, 2004, 2005) revealed the predominance of a humped curve of species richness with clear mid-elevational peak.

Most data sets analysed so far are from the tropics, both for mammals (McCaine, 2005), and other taxonomic groups as well (Rahbek, 1995). Temperate regions are underrepresented in this respect, with the majority of case studies, at least on mammals, coming from the arid regions of USA (Rickart, 2001; McCain, 2005). Europe differs from regions studied so far in lower species richness per unit area (Kryštufek, 2004) and has thus a potential to provide data for testing the validity of hypotheses proposed so far. However, surprisingly little is known in this respect for the continent which is the cradle of biological science. We report in this paper on the distribution of small non-volant mammals along an elevational gradient on Mt. Pohorje, the south-eastern most extension of the Alpine mountain chain. Our study lacked a priori standardized sampling methodology which restricted our goal to a descriptive level. Despite this we trust that conclusion from this study allow some ideas on what may be a genuine elevational pattern in small mammal assemblages on a south-European mountain of moderate elevation.

## MATERIAL AND METHODS

### Study area

Mt. Pohorje, located in northeast Slovenia, is the south-eastern most extension of the Central Alps. The west to east oriented ridge is 68 km long, but higher elevations (above 1100 m a.s.l.) are mainly an extensive plateau with rounded peaks of modest altitude (Jezerski vrh: 1537 m, Črni vrh: 1543 m). Bedrock is metamorphic and impermeable. Climate is a continental one, with cold and snowy winters at higher elevations. Close to the mountain's top (Ribniška koča, 1507 m a.s.l.), the mean annual temperature is 3.7°C, with means for the coldest and the warmest months being -5.6°C and 13.9°C, respectively. Annual rainfall is abundant (1100–1300 mm) with peaks along the central ridge (1500–1600 mm). Forest is the dominant vegetation type, but natural stands of beech *(Fagus sylvatica)* were largely transformed in the past centuries into monotonous stands of Norway spruce *(Picea abies)*. The high plateau is marshy with isolated *Sphagnum* bogs which are largely overgrown by dwarf pine *(Pinus mugo)*. Agriculture is not an intensive one and stockbreeding, in addition to forestry, is the principal traditional activity. Single farms go as high as 1270 m a.s.l.

### Material and methods

Data on local small mammal assemblages were obtained from published sources (Heneberg *et al.,* 1964; Šorgo & Janžekovič, 1995), unpublished reports and from the files of the Slovenian Museum of Natural History. Field sampling was performed in 33 sites (Fig. 1) in three different ways: snap trapping, pitfall trapping and owl pellet analysis. A modified version of Museum Special snap traps was mainly used with a mixture of canned sardines and oat flakes as bait. Traps were settled in lines of various lengths (usually > 50 traps per site) and were exposed overnight. Pitfalls used were five liter buckets dug in the ground and filled with water to approximately one third to prevent escapes. Five or ten pitfalls were fixed per site and exposed over the entire vegetation season. Owl pellets of *Strix aluco* (a forest species) and *Asio otus* (hunting on meadows) were collected at suitable places and elaborated according to a standard protocol. Voucher specimens are deposited in the collections of the Slovenian Museum of Natural History (Ljubljana) and in the Department of Biology, University of Maribor.

We considered non-volant small mammals belonging to six families: Soricidae, Talpidae, Erinaceidae, Cricetidae (Arvicolinae), Muridae, and Gliridae. Taxonomy and nomenclature follow Wilson & Reeder (2005). Species presence/absence matrix was constructed according to 200 m intervals (hereafter elevational intervals). We assumed that species occurred at an elevation if they were detected at both higher and lower elevation intervals. Intervals of 200 m proved sensitive enough to detect changes in the assemblages of species on the one hand, with a reasonably low share of empty intervals on the other.

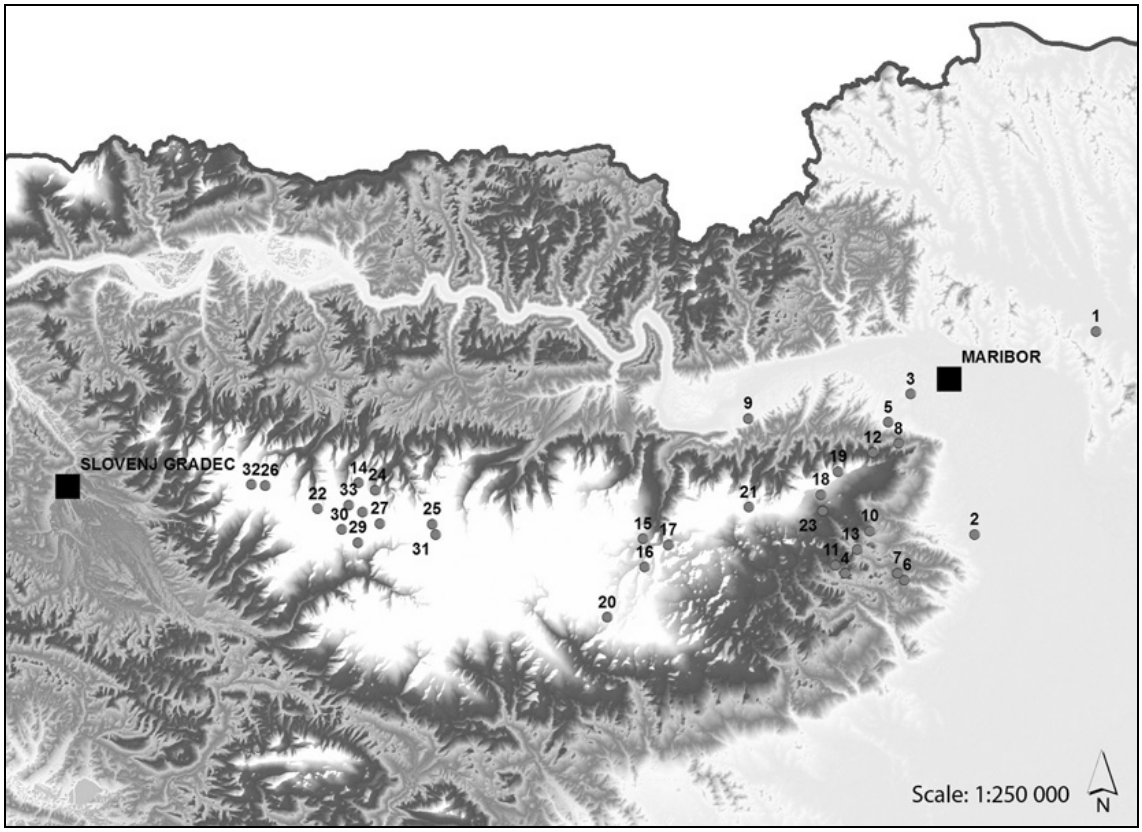


***Fig. 1: Study area with sampling localities shown by dots. For list of localities see Appendix 1.***
***Sl. 1: Proučevano območje z vrisanimi mesti vzorčenja. Popoln seznam nahajališč je podan v Dodatku 1.***

Species turnover (β diversity) across the elevational gradient was evaluated following Whittaker (1960):

$\beta = (s/\alpha) - 1$

where $s$ is the total number of species recorded in the elevational gradient, and $\alpha$ is the average number of species within the elevational interval.

## RESULTS AND DISCUSSION

Small mammals were sampled at 33 localities, ranging in elevation between 250–300 m and 1530 m a.s.l.; see Appendix 1 for details. The majority of sites (61%) was sampled by pitfalls while owl pellets were collected on two localities only. The number of specimens per site varied between 1 and 321. Median (19) and central quartile range (6–36) were low, consequently the majority of local samples were small. There were significant differences among sample sizes regarding the sampling method. The two owl pellet samples were by far the largest (145 and 321 specimens, respectively) and snap trapping provided the majority of small samples (Tab. 1). Samples, obtained by pitfall trapping were on average significantly larger than those by snap trapping ($Z = 2.72$, $p < 0.01$; Mann-Whitney U test).

***Tab. 1: Number of small mammal specimens obtained by two trapping techniques. N – number of sites sampled.***
***Tab. 1: Število malih sesalcev, ujetih z dema različnima metodama vzorčenja. N – število vzorčenih lokacij.***

| Survey technique | N | Median | Min - Max | Central quartiles |
|---|---|---|---|---|
| Snap trapping | 11 | 4 | 1 – 98 | 1 – 14 |
| Pitfall trapping | 20 | 24 | 4 – 72 | 16 – 35.5 |

In total, 1268 specimens were collected belonging to 22 species. On the basis of a current knowledge of small mammal distributions in Slovenia (Kryštufek, 1991) we assume that the faunal list is complete. Reiser (1933) reports for Pohorje also *Eliomys quercinus*, but this record is far outside the current range and is thus unlikely (Kryštufek, 2003). Two species *(Rattus rattus, Mus musculus)* are clearly associated with human settlements in this part of Slovenia (Kryštufek, 1991) and are excluded from further consideration for this reason. Their presence is only evidenced from a few owl pellet remnants.

Species composition in a sample clearly depended on a method used in faunal survey. Sampling by pitfalls and the owl pellet analysis approached closely to a total species pool of 22 species, while snap trapping emerged as being the least effective in this respect. Such a perception is likely biased however, because much less specimens were collected by snap trapping than by the two other techniques (Append. 2). As evident from Table 2, rodents strongly dominated in samples collected by snap traps (89.2% of specimens) and in owl pellets (93.9%). High share of voles (Arvicolinae) in owl pellet sample results from prey by *Asio otus*, which is known to be specialized on this particular rodent group (Andrews, 1990). Snap trapping was evidently not effective in sampling dormice (Gliridae) while owl pellet analysis (1) most likely underestimated shrews (Soricidae). Pitfalls sampled shrews most effectively which is in line with published evidence (Kirkland & Krim Sheppard, 1994). The impact of sampling technique on perceived small mammal assembly is well known (Maddock, 1992; Kirkland & Krim Sheppard, 1994; Torre *et al.*, 2004) consequently our results are not surprising in this respect.

***Tab. 2: Frequency composition (share of specimens; in %) of pooled samples across taxonomic groups and according to the technique employed in field survey. Moles (Talpidae) and hedgehogs (Erinaceidae) were excluded. See also Appendix 2 for a species composition of samples.***
***Tab. 2: Frekvenčna sestava (delež osebkov; v %) v združenih vzorcih, urejenih po taksonomskih skupinah in po metodi terenskega vzorčenja. Krti (Talpidae) in ježi (Erinaceidae) niso vključeni. Glej Dodatek 2 za vrstno sestavo vzorcev.***

| | Snap trapping | Pitfall trapping | Owl pellets |
|---|---|---|---|
| Soricidae | 10.8 | 37.7 | 6.1 |
| Arvicolinae | 44.3 | 19.5 | 58.2 |
| Muridae | 43.8 | 40.2 | 27.0 |
| Gliridae | 1.1 | 2.6 | 8.7 |
| Total | 100.0 | 100.0 | 100.0 |

Fourteen species of a total 20 occurred all along the elevational gradient but the statement is poorly documented for *Talpa europaea, Arvicola scherman, Microtus arvalis* and *Glis glis*. Noteworthy, 19 species were found in the lowest elevational zone, *i.e.*, all but *Dryomys nitedula* and we believe that the absence of this dormouse from low elevations is genuine. Altitudinal range for *Micromys minutus* is puzzling. Pitfall sampling confirmed its presence at low elevations (< 600 m a.s.l.), but remnants of two specimens were recorded in *A. otus* pellets at 1450 m a.s.l. Although this mouse does ascend as high as 1700 m a.s.l. in the southern Balkans (Kryštufek & Kovačić, 1984), it was not recorded above 900 m in Austria (Spitzenberger, 2001). In subsequent analyses we thus considered *M. micromys* to be restricted only to the lowest two elevational zones. The remaining four species gradually disappeared with increasing altitude: *Crocidura leucodon* and *C. suaveolens* at 700 m, *Erinaceus roumanicus* at 1100 m, and *Neomys anomalus* at 1130 m a.s.l. In conclusion, the core species are best classified as elevational generalists. With the exception of *Dryomys nitedula*, not a single species was added to the regional species pool with the increasing elevation. As a result, the overall turnover rate is excessively low ($\beta = 0.17$).

The overall elevational pattern in species richness on Mt. Pohorje is thus a steady decline in species numbers along the altitudinal gradient (Tab. 3, Fig. 1). Species richness also correlated negatively and significantly with elevation ($r = -0.931$, $p < 0.01$). Although such a response of species richness was long considered to be a general pattern in mountain biotas (MacArthur, 1972) and is certainly common in some taxonomic groups (Körner, 2002), the majority of recent studies, those based on small mammals in particular, demonstrate the predominance of a humped curve pattern (*cf.* McCain, 2005, and references therein). Possible reason for a deviation from the humped pattern might be lack of high elevation generalists, but this requires further evaluation on the continental scale. The decline might also be due to decrease in primary productivity (Körner, 2002). Presumption that species diversity increases with overall

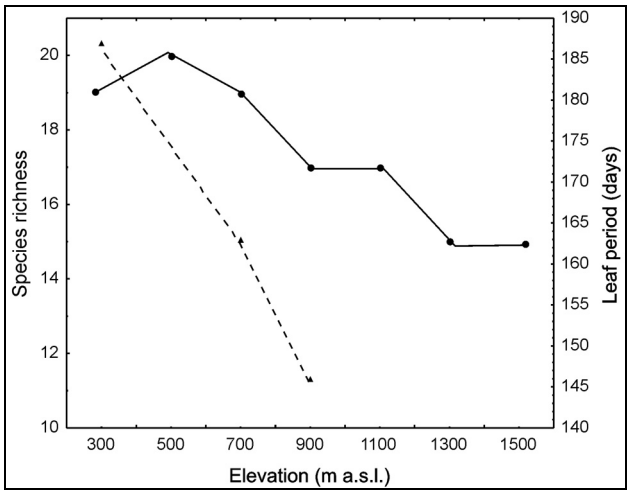


***Fig. 2: Bivariate plot of small mammal species richness on Mt. Pohorje (dots) and of the period the beech is in leaf (triangles) against elevation.***
***Sl. 2: Število vrst malih sesalcev na Pohorju (pike) in trajanje olistanosti bukve (trikotniki) glede na nadmorsko višino.***

***Tab. 3: Small mammal species composition according to 200 m elevational zones on Mt. Pohorje. X – evidence based on trapping; O – evidence from owl pellets; not sign (--) – presence presumed; S – species richness ($S_{total}$ = 20). Predicted species richness accounts also presumed presences.***
***Tab. 3: Vrstna sestava malih sesalcev na Pohorju po posameznih 200 metrskih višinskih pasovih. X – podatek temelji na ulovu; O – podatek temelji na izbljuvkih sov; pomišljaj (--) – domnevna prisotnost S – število vrst ($S_{total}$ = 20). Ocenjeno število vrst vključuje tudi domnevne prisotnosti.***

| Elevational midpoint | 300 | 500 | 700 | 900 | 1100 | 1300 | 1500 |
|---|---|---|---|---|---|---|---|
| *Sorex araneus* | X | X | X | X | X | X | X |
| *Sorex minutus* | X | X | X | X | X | X | X |
| *Sorex alpinus* | X | X | -- | X | X | X | X |
| *Neomys fodiens* | X | X | X | -- | X | X | X |
| *Neomys anomalus* | X | X | O | -- | X | | |
| *Crocidura leucodon* | X | -- | O | | | | |
| *Crocidura suaveolens* | -- | -- | O | | | | |
| *Talpa europaea* | -- | X | X | -- | X | -- | X |
| *Erinaceus roumanicus* | -- | -- | -- | -- | X | | |
| *Myodes glareolus* | X | X | X | X | X | X | X |
| *Arvicola scherman* | X | -- | O | -- | -- | -- | O |
| *Microtus agrestis* | X | X | X | X | X | X | X |
| *Microtus arvalis* | X | -- | O | -- | -- | -- | O |
| *Microtus subterraneus* | X | X | X | -- | X | X | X |
| *Apodemus flavicollis* | X | X | X | X | X | X | X |
| *Apodemus sylvaticus* | X | X | X | X | X | -- | O |
| *Micromys minutus* | X | X | | | | | O |
| *Muscardinus avellanarius* | X | -- | X | X | X | -- | X |
| *Dryomys nitedula* | | X | X | X | X | -- | X |
| *Glis glis* | -- | -- | X | -- | -- | -- | O |
| Empirical S | 15 | 13 | 17 | 9 | 14 | 8 | 15 |
| Predicted S | 19 | 20 | 19 | 17 | 17 | 15 | 15 |

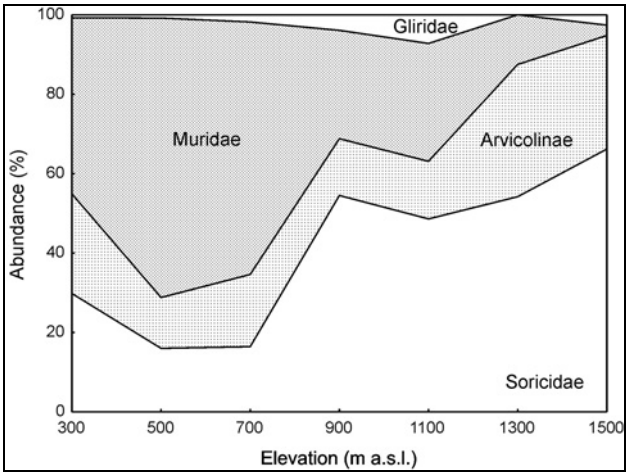


***Fig. 3: Frequency distribution (relative abundance) of main small mammal groups along the elevational gradient on Mt. Pohorje.***
***Sl. 3: Frekvenčna razporeditev (relativna številčnost) glavnih skupin malih sesalcev vzdolž višinskega gradienta na Pohorju.***

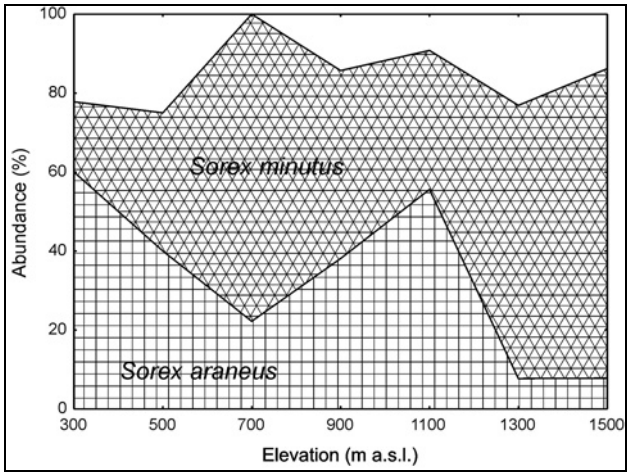


***Fig. 4: Frequency distribution (relative abundance) along the elevational gradient on Mt. Pohorje of*** *Sorex araneus* ***and*** *Sorex minutus* ***within shrew assemblages.***
***Sl. 4: Frekvenčna razporeditev (relativna številčnost) vzdolž višinskega gradienta na Pohorju vrst*** *Sorex araneus* ***in*** *Sorex minutus* ***v združbah rovk.***

productivity is one of the most widely cited causal hypotheses concerning variation in species richness (MaCArthur, 1972; Rahbek, 1995). Productivity is not easy to measure (Heaney, 2001) and data are seldom available for elevational transects. Data from the Alps of Slovenia do show decrease in a period the beech *(F. sylvatica)* is in leaf, which can be used as a proxy for the length of a productivity period. Over 45 years (1960–2004), this period lasted for 187 days at the elevation of 275 m, 163 days at 760 m, and 146 days at 970 m (data from the Environmental Agency of the Republic of Slovenia). However, the decline for the leaf period is steeper than for the species richness (Fig. 1).

The four main taxonomic groups showed a different response to increase in elevation (Fig. 2). Note also that taxonomic groups overlap with trophic groups (Kryštufek & Griffiths, 1999; 2001), *i.e.,* Soricidae are insectivorous, Arvicolinae are herbivorous, while Muridae and Gliridae are omnivorous. Pearson correlation coefficient between relative abundance and elevation was significant (at $p < 0.05$) for Soricidae ($r = 0.839$) and for Muridae ($r = -0.844$). Within shrews, *Sorex araneus* and *S. minutes* were the most abundant species throughout the elevational transect (Fig. 4). The former tended to dominate at lower elevations and the latter at higher altitudes, the trend however was not a simple one and correlations were not significant ($r < 0.67$, $p > 0.05$). Dormice (Gliridae) were rare throughout the elevational gradient (relative abundance < 10%). Noteworthy is their peak above 1000 m a.s.l. and their presence at the highest elevational zone, where even *Apodemus flavicollis*, the dominant small mammal in the study area, was rarely collected.

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# VIŠINSKA RAZPOREDITEV MALIH TERESTRIČNIH SESALCEV NA POHORJU, SLOVENIJA

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*POVZETEK*

*Na Pohorju smo vzorčili male sesalce na 33 lokacijah v nadmorskih višinah med 250–300 m in 1530 m. Vrstna sestava je bila odvisna od metode vzorčenja. Lov s pastmi na vzmet je bil učinkovitejši pri vzorčenju glodalcev, lovne jame pa pri vzorčenju rovk. V materialu smo določili 22 vrst, vendar dveh komenzalnih glodalcev* (Rattus rattus *in* Mus musculus) *nismo upoštevali pri nadaljnjih analizah. Štirinajst vrst, od skupnega števila 20, je bilo prisotnih vzdolž celotnega višinskega gradienta, vrstni obrat pa je bil zelo nizek (β = 0,17). Za višinski vzorec vrstne raznolikosti na Pohorju je bilo tako značino postopno zmanjševanje števila vrst vzdolž višinskega gradienta. Relativna številčnost miši (Muridae) je upadala z naraščajo nadmorsko višino (r = -0,844), številčnost rovk (Soricidae) pa je naraščala (r = 0,839).*

**Ključne besede:** Alpe, Pohorje, višinski razpon, mali sesalci, model mid-domain, vrstna pestrost

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***Appendix 1: Summary of faunal surveys on Mt. Pohorje (Fig. 1). Given are locality, elevation, method employed, date, total number of specimens collected and list of species with number of specimens in parentheses. List of species with acronyms: Soricidae:*** *Sorex araneus* ***(S.ar),*** *S. minutus* ***(S.mi),*** *Sorex alpinus* ***(S.al),*** *Sorex* ***sp. (S.sp),*** *Neomys fodiens* ***(N.fo),*** *Neomys anomalus* ***(N.an),*** *Crocidura suaveolens* ***(C.su),*** *C. leucodon* ***(C.le); Talpidae:*** *Talpa europaea* ***(T.eu); Erinaceidae:*** *Erinaceus roumanicus* ***(E.ro); Cricetidae, Arvicolinae:*** *Myodes glareolus* ***(M.gl),*** *Arvicola sherman* ***(A.sc),*** *Microtus agrestis* ***(M.ag),*** *M. arvalis* ***(M.ar),*** *M. subterraneus* ***(M.su),*** *Microtus* ***sp. (M.sp); Muridae:*** *Apodemus flavicollis* ***(A.fl),*** *A. sylvaticus* ***(A.sy),*** *Apodemus* ***sp. (A.sp),*** *Micromys minutus* ***(M.mi),*** *Rattus rattus* ***(R.ra),*** *Rattus* ***sp. (R.sp); Gliridae:*** *Muscardinus avellanarius* ***(M.av),*** *Dryomys nitedula* ***(D.ni),*** *Glis glis* ***(G.gl).***
***Dodatek 1: Povzetek favnističnih vzorčenj na Pohorju (Sl. 1). Navedeni so nahajališče, nadmorska višina, uporabljena metoda vzorčenja, datum, skupno število zbranih osebkov in seznam vrst s številom osebkov v oklepaju. Za seznam vrst z oznakami glej zgoraj.***

1. Maribor, Pernica, 250–300 m a.s.l.; snap trapping on 22 May 1985; N=4: *M.gl.* (1), *M.ag* (2), *A.fl* (1).
2. Slivnica, 275 m a.s.l.; pitfall sampling in 1991; N=71: *S.ar* (25), *S.mi* (5), *M.gl.* (20), *M.ar* (1), *A.fl* (19), *M.av* (1).
3. Pekre, Ledine, 280 m a.s.l.; pitfall sampling in 1987; N=55: *S.ar* (2), *S.mi* (3), *S.al* (1), *N.fo* (2), *N.an* (6), *C.le* (1), *A.sc* (2); *M.gl.* (10), *M.ag* (2), *M.su* (1), *A.fl* (11), *A.sy* (3), *A.sp* (10), *M.mi* (1).
4. Maribor, Fram, Planica, 310 m a.s.l.; snap trapping on 12 July 1977; N=1: *S.ar* (1).
5. Bolfenk, Vzpenjača, 330 m a.s.l.; pitfall sampling in 1987; N=25: *M.gl.* (1), *M.su* (1), *A.fl* (17), *A.sy* (2), *A.sp* (4).
6. Fram, 400 m a.s.l.; pitfall sampling in1991; N=59: *S.ar* (8), *S.mi* (2), *S.al* (1), *N.fo* (3), *N.an* (1), *T.eu* (1), *M.gl.* (9), *M.ag* (1), *M.su* (1), *A.fl* (30), *M.mi* (2).
7. Fram, 425 m a.s.l.; pitfall sampling in1991; N=31: *A.fl* (30), *D.ni* (1).
8. Bolfenk, Skalce, 560 m a.s.l.; pitfall sampling in 1987; N=36: *S.mi* (5), *M.gl.* (5), *A.fl* (14), *A.sy* (2), *A.sp* (10).
9. Ruše, 600–700 m a.s.l.; snapp trapping in 1963; N=98: *S.ar* (2), *T.eu* (1), *M.gl.* (40), *M.su* (1), *A.fl* (53), *D.ni* (1). Source: Heneberg *et al.* (1964).
10. Hoče – Areh, "Veronika Klinc", 675 m a.s.l.; pitfall sampling in 1991; N=55: *S.ar* (2), *S.mi* (7), *M.gl.* (10), *A.fl* (35), *G.gl* (1).
11. Planica nad Framom, 700 m a.s.l.; pellets of *Strix aluco*, collected in 1991 and 1992; N=145: *S.ar* (6), *S.mi* (1), *N.fo* (4), *N.an* (1), *C.su* (1), *C.le* (9), *T.eu* (4), *M.gl.* (14), *A.sc* (29), *M.ag* (4), *M.ar* (9), *M.su* (12), *A.fl* (5), *A.sy* (1), *A.sp* (18), *R.ra* (3), *R.sp* (1), *M.av* (3), *G.gl* (18). Source: Šorgo & Janžekovič (1995).
12. Bolfenk, Jonatan, 800 m a.s.l.; pitfall sampling in 1987; N=24: *S.ar* (1), *S.mi* (6), *N.fo* (1), *M.gl.* (4), *M.ag* (1), *A.fl* (5), *A.sy* (1), *A.sp* (4), *M.av* (1).
13. Slap na Framskem potoku, 925 m; pitfall sampling in 1991; N=35: *S.ar* (9), *S.mi* (8), *S.al* (5), *M.gl.* (5), *A.fl* (6), *D.ni* (1), *M.av* (1).
14. Predan, 975 m a.s.l.; pitfall sampling in 1991; N=18: *S.ar* (6), *S.mi* (6), *M.gl.* (1), *A.fl* (5).
15. Šumik, 1000–1100 m a.s.l.; snap trapping on 18 July 1969; N=14: *S.al* (1), *N.fo* (3), *T.eu* (1), *M.gl.* (3), *M.su* (4), *A.fl* (2).
16. Bajgot, 1050 m a.s.l.; pitfall sampling in 1991; N=4: *S.mi* (1), *M.ag* (1), *M.av* (2).
17. Šumik, 1075 m a.s.l.; pitfall sampling in 1991; N=22: *S.ar* (3), *S.mi* (6), *M.gl.* (3), *M.su* (1), *A.fl* (6), *D.ni* (3).
18. Pajkov dom, 1100 m a.s.l.; pitfall sampling in 1991; N=14: *E.ro* (1); *S.ar* (4), *S.mi* (1), *M.ag* (1), *A.fl* (6), *M.av* (1).
19. Bolfenk, Stolp, 1130 m a.s.l.; pitfall sampling in 1987; N=72: *S.ar* (23), *S.mi* (11), *S.al* (2), *N.fo* (1), *N.an* (2), *M.gl.* (5), *M.ag* (2), *M.su* (3), *A.fl* (11), *A.sy* (2), *A.sp* (8), *D.ni* (2).
20. Domna Osankarici, 1190 m a.s.l.; snap trapping on 21 June 1984; N=6: *N.fo* (1), *M.gl.* (1), *M.ag* (1), *A.fl* (3).
21. Areh, 1200–1300 m a.s.l.; pitfall sampling in 1991; N=24: *S.ar* (1), *S.mi* (9), *S.al* (3), *M.gl.* (6), *M.ag* (1), *M.su* (1), *A.fl* (3).
22. Šiklarica, Črni vrh, 1300 m a.s.l.; snap trapping on 10 Aug 1975; N=1; *S.ar* (1).
23. Grmovškov dom, 1370 m a.s.l.; snapp trapping on 7 July 1983; N=11: *S.mi* (1), *N.fo* (1), *M.gl.* (1), *M.su* (4), *A.fl* (4).
24. Ribniško jezero, 1425 m a.s.l.; pitfall sampling in 1991; N=15: *S.mi* (10), *M.gl.* (1), *M.ag* (2), *M.su* (1), *M.av* (1).
25. Lovrenško jezero, 1425 m a.s.l.; pitfall sampling in 1991; N=17: *S.ar* (2), *S.mi* (12), *M.ag* (1), *M.su* (2).
26. Velika Kopa, 1450 m a.s.l.; snapp trapping on 3–5 April 1983, 2–8 July 1993; N=37: *S.ar* (3), *S.mi* (2), *S.al* (2), *M.gl.* (1), *M.ag* (2), *M.su* (12), *A.fl* (14), *D.ni* (1).

27. Jezerski vrh, 1450 m a.s.l.; pitfall sampling in 1991; N=19: *S.mi* (8), *M.gl.* (9), *M.ag* (2).
28. Ribniško jezero, 1450 m a.s.l.; pellets of *Asio otus*, collected in 1993; N=321: *S.ar* (1), *S.mi* (4), *S.sp* (1), *M.gl.* (29), *A.sc* (3), *M.ag* (136), *M.ar* (4), *M.su* (24), *M.sp* (1), Arvicolinae inted. (3), *A.fl* (66), *A.sy* (13), *A.sp* (12), *M.mi* (2), *M.mu* (3), *M.av* (18), *G.gl* (1). Source: Šorgo & Janžekovič (1995).
29. Jezerski vrh, 1500 m a.s.l.; pitfall sampling in 1991; N=24: *S.ar* (2), *S.mi* (9), *S.al* (3), *N.fo* (3), *T.eu* (3), *M.gl.* (1), *M.su* (1), *A.fl* (2).
30. Ribniško jezero, 1500 m a.s.l.; snap trapping on 19 July 1969; N=1: *M.ag* (1).
31. Lovrenška jezera, 1520 m a.s.l.; pitfall sampling in 1987; N=5: *S.al* (1), *S.mi* (1), *M.gl.* (1), *M.ag* (1), *M.av* (1).
32. Mala Kopa, 1520 m a.s.l.; snap trapping on 13 July 1984; N=2: *S.ar* (1), *T.eu* (1).
33. Ribniška koča, 1530m a.s.l.; snap trapping on 20 July 1969; N=4: *M.su* (4).

***Appendix 2: Summary table of small mammal species and their abundance according to method employed during faunal surveys. S – species richness.***
***Dodatek 2: Pregledna tabela vrst malih sesalcev in njihove številčnosti glede na uporabljeno metodo vzorčenja. S – število vrst.***

| | **Snap trapping S = 10** | **Pitfall trapping S = 19** | **Owl pellets S = 19** | **Total S = 22** |
|---|---|---|---|---|
| *Sorex araneus* | 8 | 88 | 7 | 103 |
| *Sorex minutus* | 3 | 110 | 5 | 118 |
| *Sorex alpinus* | 3 | 17 | | 20 |
| *Sorex sp.* | | | 1 | 1 |
| *Neomys fodiens* | 5 | 9 | 4 | 18 |
| *Neomys anomalus* | | 9 | 1 | 10 |
| *Crocidura leucodon* | | 1 | 9 | 10 |
| *Crocidura suaveolens* | | | 1 | 1 |
| *Talpa europaea* | 3 | 4 | 4 | 11 |
| *Erinaceus roumanicus* | | 1 | | 1 |
| *Myodes glareolus* | 47 | 91 | 43 | 181 |
| *Arvicola scherman* | | 2 | 32 | 34 |
| *Microtus agrestis* | 6 | 15 | 140 | 161 |
| *Microtus arvalis* | | 1 | 13 | 14 |
| *Microtus subterraneus* | 25 | 12 | 36 | 73 |
| *Microtus* sp. | | | 1 | 1 |
| Arvicolinae *indet.* | | | 3 | 3 |
| *Apodemus flavicollis* | 77 | 200 | 71 | 348 |
| *Apodemus sylvaticus* | | 10 | 14 | 24 |
| *Apodemus* sp. | | 36 | 30 | 66 |
| *Micromys minutus* | | 3 | 2 | 5 |
| *Rattus rattus* | | | 3 | 3 |
| *Rattus* sp. | | | 1 | 1 |
| *Mus musculus* | | | 3 | 3 |
| *Muscardinus avellanarius* | | 8 | 21 | 29 |
| *Dryomys nitedula* | 2 | 7 | | 9 |
| *Glis glis* | | 1 | 19 | 20 |
| Total specimens | 179 | 625 | 464 | 1268 |

***Appendix 3: Summary table of small mammal numbers according to 200 m elevational zones. Based on pitfall sampling.***
***Dodatek 3: Pregledna tabela števila malih sesalcev po posameznih 200 metrskih višinskih pasovih. Temelji na vzorčenju z lovnimi jamami.***

| Elevational midpoint | 300 | 500 | 700 | 900 | 1100 | 1300 | 1500 | Total |
|---|---|---|---|---|---|---|---|---|
| *Sorex araneus* | 27 | 8 | 2 | 16 | 30 | 1 | 4 | 88 |
| *Sorex minutus* | 8 | 7 | 7 | 20 | 19 | 9 | 40 | 110 |
| *Sorex alpinus* | 1 | 1 | | 6 | 2 | 3 | 4 | 17 |
| *Neomys fodiens* | 2 | 3 | | | 1 | | 3 | 9 |
| *Neomys anomalus* | 6 | 1 | | | 2 | | | 9 |
| *Crocidura leucodon* | 1 | | | | | | | 1 |
| *Talpa europaea* | | 1 | | | | | 3 | 4 |
| *Erinaceus roumanicus* | | | | | 1 | | | 1 |
| *Myodes glareolus* | 31 | 14 | 10 | 10 | 8 | 6 | 12 | 91 |
| *Arvicola scherman* | 2 | | | | | | | 2 |
| *Microtus agrestis* | 2 | 1 | | 1 | 4 | 1 | 6 | 15 |
| *Microtus arvalis* | 1 | | | | | | | 1 |
| *Microtus subterraneus* | 2 | 1 | | | 4 | 1 | 4 | 12 |
| *Apodemus flavicollis* | 47 | 74 | 35 | 16 | 23 | 3 | 2 | 200 |
| *Apodemus sylvaticus* | 5 | 2 | | 1 | 2 | | | 10 |
| *Apodemus* sp. | 14 | 10 | | 4 | 8 | | | 36 |
| *Micromys minutus* | 1 | 2 | | | | | | 3 |
| *Muscardinus avellanarius* | 1 | | | 2 | 3 | | 2 | 8 |
| *Dryomys nitedula* | | 1 | | 1 | 5 | | | 7 |
| *Glis glis* | | | 1 | | | | | 1 |
| Total specimens | 151 | 126 | 55 | 77 | 112 | 24 | 80 | 625 |

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# CONTRIBUTION TO THE KNOWLEDGE ON THE LONGHORN BEETLE (COLEOPTERA, CERAMBYCIDAE) FAUNA OF VOZILIĆI, EASTERN ISTRIA, CROATIA

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## *ABSTRACT*

*Between the years 1973 and 1982, a faunistic survey of longhorn beetles (Cerambycidae) fauna was conducted in Vozilići, eastern Istria. Altogether 250 specimens, belonging to 38 species were collected. The first systematic list of cerambycid fauna of Vozilići is given, along with their biogeographical affiliation. Turanic-European and Turanic-European Mediterranean species prevailed. We recorded also* Cerambyx cerdo *Linnaeus, 1758, a vulnerable species at European scale. Most interesting is the finding of* Semanotus russicus *(Fabricius, 1776), which has so far been found only in two places in Croatia.*

**Key words:** Cerambycidae, *Cerambyx cerdo, Semanotus russicus*, Istria, Vozilići

# CONTRIBUTO ALLA CONOSCENZA DI CERAMBICIDI (COLEOPTERA, CERAMBYCIDAE) A VOZILIĆI, ISTRIA ORIENTALE, CROAZIA

*SINTESI*

*Negli anni fra il 1973 ed il 1982 è stata condotta una ricerca faunistica sui Cerambicidi (Cerambycidae) nella località di Vozilići, Istria orientale. Sono stati raccolti 250 esemplari appartenenti a 38 specie. L'articolo riporta la prima lista sistematica dei Cerambicidi di Vozilići, accompagnata dalla loro affiliazione biogeografia. Fra le specie trovate si è riscontrata la prevalenza di quelle turanico-europee e turanico-europee-mediterranee. Gli autori sottolineano pure il ritrovamento di* Cerambyx cerdo *Linnaeus, 1758, specie vulnerabile su scala europea. Molto interessante, inoltre, la segnalazione della presenza di* Semanotus russicus *(Fabricius, 1776), specie precedentemente ritrovata solamente in due località croate.*

**Parole chiave:** Cerambycidae, *Cerambyx cerdo, Semanotus russicus*, Istria, Vozilići

## INTRODUCTION

Longhorn beetles (Cerambycidae) are one of the most numerous beetle (Insecta, Coleoptera) families, with an estimation of 35,000 species worldwide (Lawrence, 1982). Larvae of cerambycids are usually xylophagus and feed on dying or dead trees and thus are ecologically a very important group (Duffy, 1953; Linsley, 1959; Hanks, 1999). However, some species are known to feed on healthy or weakened trees as well (Craighead, 1950; Keen, 1952). Many species declined and became endangered in many parts of Europe (Evans *et al.*, 2004).

The first systematic faunistic overview of Cerambycidae in former Yugoslavia, including Croatia, was prepared by Mikšić (1963) and was later supplemented by Von Demelt & Schurmann (1964), Novak (1964), Mikšić & Georgijević, (1971, 1973), and Mikšić & Korpič (1985). According to Mikšić & Georgijević (1971), the longhorn beetle fauna of Croatia counts at least 225 species. The fauna of longhorn beetles (Cerambycidae) of Istria was never systematically studied, and only sporadic findings were published during the 20th century (Depoli & Goidanich, 1926; Depoli, 1940; Müller, 1953; Mikšić, 1963; Von Demelt & Schurmann, 1964). Recently, only data for the Slovenian part of Istria were reviewed (Brelih *et al.*, 2006).

We are presenting the first list of longhorn beetles of Vozilići in eastern Istria along with the biogeographical, ecological and conservation remarks given.

## MATERIALS AND METHODS

This research was conducted from 1972 to 1982 in the planted mixed forest of *Pinus nigra* Arnold and *Pinus helepensis* Mill, near the village of Vozilići in eastern Istria (Fig 1.) at the elevation of approximately 80 m altitude. The undergrowth of mixed *Pinus* forest was composed mainly of maquis vegetation, as well as young *Carpinus orientalis* and *Quercus pubescens* trees.

The area of Vozilići belongs to the submediteranean region of Istria (Šugar, 1984). According to Šegota & Filipčić (2003), the climate of the area is classified as Köppen's Cfb climate, meaning moderate warm and humid climate with warm summers.

Only occasional, non-systematic samplings of beetles were conducted, few times a year between May and July. Longhorn beetles were collected by a combination of standard methods for collecting insects, including net sweeping, light traps, fragrant bait and hand netting on the trees, bushes, grasses and flowers. For the fragrant bait, a mixture of cherry liquor and rotten meat was used (Champlain & Kirk, 1926).

Species determination was done using different identification keys (Mikšić & Georgijević, 1971, 1973; Mikšić & Korpič 1985; Bense, 1995; Chatenet, 2000) and comparative material from museum collections (Novak, Koča) of the Croatian Natural History Museum. Beetles were classified following Fauna Europaea (2010). Biogeographical analysis was done according to Brelih *et al.* (2006). Because the conservation status of longhorn beetles in Croatia has never been accessed due to the lack of suitable data, we compared our data with Brelih *et al.* (2006) for conservation status in Slovenia. All longhorn beetle specimens were preserved in beetle collection of Croatian Natural History Museum (F. Perović), with the label "Cerambycidae Vozilići".


***Fig. 1: Map of Croatia with the position of Istria and Vozilići.***
***Sl. 1: Zemljevid Hrvaške z izsekom Istre in označeno lokacijo Vozilićev.***

## RESULTS AND DISCUSSION

During this research, 250 specimens were collected altogether, from which 38 longhorn beetle species were identified. The systematic list of found species, along with the collecting dates and biogeographical affiliation is given in Table 1. Biogeographical analysis showed the prevalence of Turanic-European species (21%), followed by Turanic-European-Mediterranean (16%), Asian-European (13%), European-Mediterranean (13%), Southern European (8%), European (8%), Siberian-European (5%) and Paleartic (5%). All other zoogeographical affiliations were represented by a single species and consisted only of 3%.

***Tab. 1: List of longhorn beetles (Cerambycidae) collected in Vozilići between 1973 and 1982 along with the dates of finding and biogeographical affiliation.***
***Tab. 1: Seznam kozličkov (Cerambycidae) zbranih v Vozilićih med letoma 1973 in 1982, skupaj z datumi najdb in njihovo biogeografsko pripadnostjo.***

| No. | Species | Label dates on specimens | Biogeography |
|---|---|---|---|
| **Cerambycinae** | | | |
| 1 | *Cerambyx cerdo* Linnaeus, 1758 | 07.07.1975, 12.06.1977 | Turanic-European-Mediterranean |
| 2 | *Poecilium pusillum* (Fabricius, l787) | 16.11.1975 | Turanic-European |
| 3 | *Phymatodes testaceus* (Linnaeus, 1758) | 09.06.1976 | European-Mediterranean |
| 4 | *Poecilium alni* (Linnaeus, 1767) | 03.05.1975 | Turanic-European |
| 5 | *Pyrrhidium sanguineum* (Linnaeus, 1758) | 03.05.1975 | European-Mediterranean |
| 6 | *Ropalopus clavipes* (Fabricius, 1775) | 21.06.1975, 13.06.1977, 30.06.1978 | Asian-European-Mediterranean |
| 7 | *Semanotus russicus* (Fabricius, 1776) | 16.11.1975 | Mediterranean |
| 8 | *Hylotrupes bajulus* (Linnaeus, 1758) | 06.06.1977 | Palaearctic |
| 9 | *Chlorophorus figuratus* (Scopoli, 1763) | 21.06.1982 | European |
| 10 | *Chlorophorus sartor* (Müller, 1766) | 20.07.1982 | Turanic-European-Mediterranean |
| 11 | *Chlorophorus varius* (Müller, 1766) | 10.08.1979 | Turanic-European-Mediterranean |
| 12 | *Clytus rhamni* Germar, 1817 | 29.06.1978, 21.06.1982 | Turanic-European-Mediterranean |
| 13 | *Neoclytus acuminatus* (Fabricius, 1775) | 05.05.1976, 21.06.1982 | Nearctic |
| 14 | *Plagionotus arcuatus* (Linnaeus, 1758) | 18.06.1977, 29.06.1978 | Turanic-European-Mediterranean |
| 15 | *Plagionotus floralis* (Pallas, 1776) | 12.07.1976 | Asian-European |
| 16 | *Purpuricenus budensis* (Goeze, 1783) | 05.06.1975, 19.06.1975, 20.07.1982 | Southern European-Mediterranean |
| 17 | *Purpuricenus kaehleri* (Linnaeus, 1758) | 12.07.1976, 13.06.1977, 06.06.1978, 24.07.1980, 20.07.1982 | Turanic-European |
| 18 | *Stenopterus rufus* Linnaeus, 1767 | 27.06.1974, 27.06.1975, 09.06.1976, 12.06.1977, 30.06.1978 | European-Mediterranean |
| **Lamiinae** | | | |
| 19 | *Pedestredorcadion arenarium* (Scopoli, 1763) | 03.05.1975, 15.05.1975, 31.05.1975, 21.06.1975 | Southern European |
| 20 | *Agapanthia cynarae* (Germar, 1817) | 27.06.1974, 20.06.1975, 06.07.1975, 09.06.1976, 27.06.1977 | Southern European |
| 21 | *Saperda punctata* (Linnaeus, 1767) | 13.06.1977, 30.06.1978 | European-Mediterranean |
| 22 | *Phytoecia virgula* (Charpentier, 1825) | 15.05.1975, 01.06.1975, 20.06.1975, 21.05.1976, 25.05.1977 | Turanic-European-Mediterranean |
| 23 | *Tetrops praeustus* (Linnaeus 1758) | 03.08.1975, 21.05.1976 | Siberian-European-Mediterranean |

| No. | Species | Label dates on specimens | Biogeography |
|---|---|---|---|
| **Spondylidinae** | | | |
| 24 | *Arhopalus ferus* (Mulsant, 1839) | 20.07.1975, 21.08.1976, 20.08.1979 | Asian-European |
| 25 | *Anisarthron barbipes* (Schrank, 1845) | 21.06.1975 | European |
| **Lepturinae** | | | |
| 26 | *Alosterna tabacicolor* (De Geer, 1775) | 26.05.1977, 15.05.1975 | Siberian-European |
| 27 | *Pachytodes erraticus* (Dalman, 1817) | 21.06.1975 | Asian-European |
| 28 | *Paracorymbia fulva* (De Geer, 1775) | 27.06.1974 | European |
| 29 | *Pseudovadonia livida* (Fabricius, 1776) | 27.06.1974, 20.06.1975, 12.06.1977 | Asian-European |
| 30 | *Rutpela maculata* (Poda, 1761) | 12.07.1973, 20.06.1975, 12.06.1977, 30.06.1978 | Turanic-European |
| 31 | *Stenurella bifasciata* (Müller, 1776) | 13.07.1973, 27.06.1974, 21.06.1975, 22.07.1975 | European-Mediterranean |
| 32 | *Stenurella nigra* (Linnaeus, 1758) | 16.05.1975, 21.05.1976, 25.05.1977 | Turanic-European |
| 33 | *Stenurella septempunctata* (Fabricius 1792) | 20.06.1975, 07.07.1977 | Turanic-European |
| 34 | *Stictoleptura rubra* (Linnaeus, 1758) | 27.06.1974, 22.07.1975, 20.07.1979, 21.06.1982, 20.07.1982 | Palaearctic |
| 35 | *Stictoleptura cordigera* (Fuessly, 1775) | 22.07.1975, 24.07.1975, 24.07.1980 | Turanic-European |
| 36 | *Vadonia imitatrix* Daniel, 1891 | 30.06.1978 | Southern-European |
| 37 | *Dinoptera collaris* (Linnaeus, 1758) | 02.05.1975, 21.05.1976 | Asian – European |
| 38 | *Grammoptera ruficornis* (Fabricius, 1781) | 03.05.1975 | Turanic-European |

***Fig. 2: Rare longhorn beetle, Semanotus russicus (Fabricius, 1776) found in Juniperus stumps.***
***Sl. 2: Redka vrsta kozlička Semanotus russicus (Fabricius, 1776), najdena med debli brina.***

Eight recorded species can be found in the whole Mediterranean region of Croatia: *Clytus rhamni* Germar, 1817, *Neoclytus acuminatus* (Fabricius, 1775), *Purpuricenus budensis* (Goeze, 1783), *Pedestredorcadion arenarium* (Scopoli, 1763), *Agapanthia cynarae* (Germar, 1817), *Arhopalus ferus* (Mulsant, 1839), *Vadonia imitatrix* Daniel, 1891 and *Grammoptera ruficornis* (Fabricius, 1781). Three species are present in the whole Croatia except the Mediterranean region: *Plagionotus arcuatus* (Linnaeus, 1758), *Saperda punctata* (Linnaeus, 1767) and *Stictoleptura rubra* (Linnaeus, 1758). One species, *Semanotus russicus* (Fabricius, 1776) (Fig. 2) has been so far found only in southern Istria (Vozilići), Lošinj and Dalmatia (Mikšić & Georgijević, 1973). This was the only species recorded in Vozilići, which was not recorded in the Slovenian part of Istria (Brelih *et al.*, 2006). Five adult specimens of this species were collected from the chopped *Juniperus oxycedrus* L. stump in November 1975. Later, no other specimen of *S. russicus* was found in the area.

For three recorded species a decline has been observed in Slovenia, namely *Ropalopus clavipes* (Fabricius, 1775), *Chlorophorus sartor* (Müller, 1766) and *Anisarthron barbipes* (Schrank, 1845), while two species are considered rare, namely *Poecilium pusillum* (Fabricius, l787) and *Clytus rhamni* Germar, 1817. Those species were also quite rare in the surveyed area.

We also recorded an endangered species at European scale, *Cerambyx cerdo* Linnaeus, 1758. This species is listed in IUCN Red List (2010) as vulnerable due to its known and possible future population reduction because of the decline in the area of occupancy. It is also listed in the Habitat directive Annexes II and IV (Anonymus, 1992). According to Brelih *et al.* (2006) *C. cerdo* is quite rare in the majority of Slovene regions, but more common in Istria. Its status in Croatia is unknown.

Despite our research, it is clear that the list of species is far from complete. This can be assigned to the selective field methods used to collect beetles, as well as the lack of research in other parts of the year (*e.g.* early spring). Because this research was done 40 years ago, the results are somehow outdated, but can be used in further studies of longhorn beetles in the area, especially for the comparison with the recent state of longhorn beetles fauna.

# PRISPEVEK K POZNAVANJU FAVNE KOZLIČKOV (COLEOPTERA, CERAMBYCIDAE) V VOZILIĆIH, VZHODNA ISTRA, HRVAŠKA

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*POVZETEK*

*Med letoma 1973 in 1982 je bila opravljena raziskava hroščev kozličkov (Coleoptera: Cerambycidae) v kraju Vozlići, Istra, Hrvaška. Zbranih je bilo 250 primerkov 38 različnih vrst iz družine Cerambycidae. Podan je prvi sistematični pregled kozličkov skupaj z njihovo biogeografsko pripadnostjo. Prevladujejo turansko-evropske in turansko-evpropsko-sredozemske vrste. Ena od vrst,* Cerambyx cerdo *Linnaeus, 1758, ima občutljiv status v Evropi. Zanimiva je tudi ugotovljena prisotnost redkega hrošča vrste* Semanotus russicus *(Fabricius, 1776), ki so ga poprej našli le na dveh nahajališčih na Hrvaškem.*

**Ključne besede:** Cerambycidae, *Cerambyx cerdo, Semanotus russicus*, Istra, Vozilići

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# HISTORICAL OCCURRENCE OF THE HOODED/CARRION CROW *(CORVUS CORNIX/CORONE)* IN URBAN AREAS OF EUROPE WITH EMPHASIS ON SLOVENIA

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## *ABSTRACT*

*In order to establish past changes in the status of the Hooded* (Corvus cornix) *and Carrion Crow* (Corvus corone) *in urban areas of Europe, an overview of historical sources regarding species biology and ecology from the ancient period to nowadays with special emphasis to Slovenia is given. In written sources related to five historical time periods, the species status and frequency of occurrence in urban environments (breeding, winter period) was checked as well as the Crow-Human interactions over time. The Hooded/Carrion Crow was known as an urban breeding bird from the ancient times till 18$^{th}$ century, when it disappeared from the cities. The recolonisation of urban areas started at the end of 19$^{th}$ century and is still in progress.*

**Key words:** *Corvus cornix*, *Corvus corone*, urban population, historical analysis, Europe, Slovenia

# PRESENZA STORICA DI CORNACCHIE GRIGIA E NERA *(CORVUS CORNIX/CORONE)* IN AREE URBANE EUROPEE, CON PARTICOLARE ATTENZIONE ALLA SLOVENIA

## *SINTESI*

*Al fine di stabilire variazioni nello stato della cornacchia grigia* (Corvus cornix) *e della cornacchia nera* (Corvus corone) *in aree urbane dell'Europa nel passato, l'articolo presenta una rassegna delle fonti storiche che trattano la biologia e l'ecologia delle due specie, dall'antichità fino ai giorni nostri, con particolare attenzione al territorio sloveno. Sono state esaminate le fonti stampate che si riferiscono a cinque periodi storici, al fine di trovare dati sullo stato delle specie e sulla frequenza di avvistamento in ambienti urbani (riproduzione, periodo invernale), nonché testimonianze di interazioni fra corvidi ed umani. La cornacchia grigia e quella nera sono specie che si riproducono in aree urbane e pertanto erano conosciute dall'antichità fino al diciottesimo secolo, quando sono sparite dalle città. La ricolonizzazione delle aree urbane è cominciata verso la fine del diciannovesimo secolo ed è attualmente ancora in progresso.*

**Parole chiave: Parole chiave:** *Corvus cornix*, *Corvus corone*, popolazione urbana, analisi storica, Europa, Slovenia

## INTRODUCTION

Despite the fact that urbanization always results in destruction of natural ecosystems and habitats, it also creates new ecosystem with very unique abiotic and biotic characteristics, *e.g.,* relatively large and specific food sources or lack of predators (Tarman, 1992; Shochat *et al.*, 2004). This new synthetic environment is opened to colonisation of species, which are able to use specific resources and are adaptable to the changing environment (Emlen, 1974). Urban fauna is thus represented by synanthropic species adapted to the life in or near human settlements. Faunal structure is substantially changed in urbanisation gradient (Emlen, 1974; Beissinger & Osborne, 1982; Niemelä *et al.*, 2002; Tratalos *et al.*, 2007). The assemblage structure is alternating according to the urbanisation sensibility of species, and in birds three species groups were identified (Crooks *et al.*, 2004): (1) urbanisation-enhanced (species reaching the highest density in urban environment), (2) urbanisation-intermediate (suburban species reaching the highest density in nonurban habitat patches inside urban areas), and (3) urbanisation-sensitive (species reaching the highest density outside urban areas). In general, urban areas are settled by native species from neighbouring natural ecosystems (Evans *et al.*, 2009; Loss *et al.*, 2009). Among the native species which have successfully colonized urban areas in Europe are the Hooded (*Corvus cornix*) and Carrion Crow (*Corvus corone*) (Houston, 1997).

The Hooded and Carrion Crows are middle sized corvids (48–56 cm; Madge & Burn, 1994). Until recently, their taxonomic position was unclear. The Hooded Crow was regarded as a subspecies of the Carrion Crow, but with recent genetic studies both taxa were recognized as clearly separate species (reviewed in Vrezec, 2005). However, it is still not possible to separate them in some specific studies, *e.g.,* taphonomic studies of skeleton material (Tomek & Bochenski, 2000). The distribution range of both species in Europe is more or less parapatric, with a narrow zone of contact (Svensson *et al.*, 2009). Therefore for the discussed regions it is usually the case of one species being common and the other rare or even absent. Although both crow taxa were recognized already in the older ornithological literature (Fig. 1), the biology and ecology was usually described only for one taxon, the one more common for the studied region, or both taxa were simply dealt with together (*e.g.,* Houston, 1997). For the purpose of this study I therefore regard both species together in order to reveal a better insight into the crow inhabitation of human settlements across Europe over time, taking into account larger amount of sources with different level of crow taxa consideration. In the following I will refer to the combined Hooded/Carrion Crow taxa as Crow, and as separate species only in cases when it is relevant.

Both crow species inhabit urban areas, although synanthropy is more conspicuous in the Hooded than in the Carrion Crow (Madge & Burn, 1994). However, they were widespread in Europe already in the Lower Pleistocene period more than 730,000 years ago and before large human expansion (Tyrberg, 1998; Boev, 2009). This indicates that they were not human followers or in the past introduced exotic species, which are usually more related to human presence.

Although some species closely related to the Crow are typical urbanisation-enhanced birds, *e.g.,* American Crow *(Corvus bracyhrhynchus)* (Crooks *et al.*, 2004), this is not true for the Crow. Urban areas appeared to be suboptimal habitat for the discussed species since the breeding success in urban environments is much lower compared to non-urban habitats (Richner, 1989). Many studies claim that Crows actually colonized urban areas

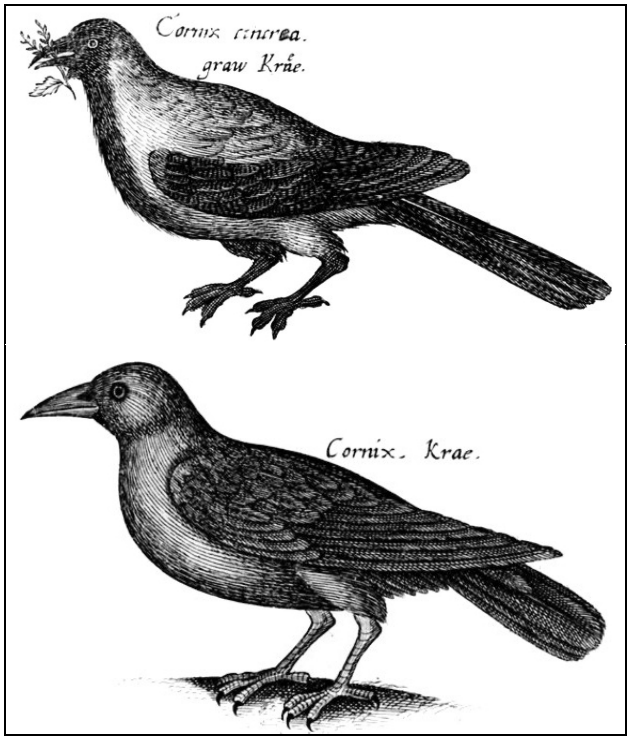


***Fig. 1: The Hooded Crow** (Corvus cornix**; Cornix cinerea. graw Krae.) and Carrion Crow** (Corvus corone**; Cornix. Krae.) were recognized taxa already in older ornithological literature (an example from Jonston, 1650).***
***Sl. 1: Siva vrana** (Corvus cornix**; Cornix cinerea. graw Krae.) in črna vrana** (Corvus corone**; Cornix. Krae.) sta bili ločeno prepoznani že v starejši ornitološki literaturi (primer iz Jonston, 1650).***

in some parts of Europe only recently, in 20th century, due to the species population increase and significant habitat changes in the cities in the last 100 years (Tomialojć & Stawarczky, 2003; Vuorisalo *et al.*, 2003; PECBMS, 2009). The aim of this study is to describe the status of the Crow in urban areas of Europe from the ancient period to nowadays. The author has overviewed historical sources with special emphasis on Slovenia, where nowadays the Hooded Crow is one of the most common bird species (Geister, 1995).

## METHODS

In the analysis of historical sources on the Crow occurrence in urban areas, the whole Europe was taken into account with special emphasis given to the region of Southern Europe and Slovenia. Five time periods were considered (Tab. 1). Data were obtained from different written sources, which considered the Hooded or Carrion Crow or Crow in general in a given time period (Tab. 1). Most of the written sources from the period of 16th to 18th century were obtained from the Gottingen State and University Library online system of digitalized documents (http://gdz.sub.uni-goettingen.de). In the recent period of 20th–21st century the amount of sources is incomparably larger than in other periods, therefore only avifaunal works of some larger areas, *i.e.,* European or national ornithological atlases, and ornithological atlases of cities were considered. The frequency of the Crow occurrence during breeding and non-breeding period in urban areas was estimated as a proportion of sources confirming species urban presence. Additionally, for the explanation of urban conditions in the past and crow-human interactions, also some artistic works were considered, *e.g.,* wall paintings (caves, frescos, Roman garden paintings), illuminations in handwritings, sculptures and other animal imaginations.

From the sources the following data were extracted: (1) occurrence and species status in urban environments (breeding, winter period), and (2) the type of crow--human interaction. For the purpose of this study, all kinds of small or large groups of man-made buildings inhabited by humans were considered urban environment, even though ancient Greek or Roman settlements would probably be classified as suburban according to the nowadays standards. The relevant point in defining urban environment was therefore synthetic or artificial environment in which colonizing wild animals are at least partly using human produced sources and are in frequent contacts with human population.

***Tab. 1: Historical time periods and the list of considered written sources for each period.***
***Tab. 1: Določitev zgodovinskih obdobij in seznam pregledanih virov za posamezna obdobja.***

| Period | Time frame | Considered sources |
|---|---|---|
| Ancient period | 7th century BC – 5th century AD | Aristoteles, Plinius, Jashemski & Meyer (2002), Foufopoulos & Litinas (2005) |
| Middle Ages and Renaissance | 6th – 17th century | Gesner (1555), Aldrovandus (1646), Jonston (1650), Willoughby (1676), Ray (1713) |
| 18th century | 18th century | Linnaeus (1746, 1758), Klein (1750), Kramer (1756), Brisson (1763), Pennant (1768), Scopoli (1769), Buffon (1788) |
| 19th century | 19th century | Seidensacher (1858, 1864), Erjavec (1870), Fritsch (1870), Savi (1873), Brehm (1879), Gjurašin (1899), Blasius *et al.* (1905), Reiser & von Führer (1896), Reiser (1894, 1905, 1925, 1939) |
| 20th and 21st century | 1900–2009 | Parslow (1973), Matvejev (1976), Witt (1984), Sovinc (1994), Geister (1995), Rabosee (1995), Spadea (1995), Cignini & Zapparoli (1996), Biagioni *et al.* (1996), Kuzniak (1996), Handrinos & Akriotis (1997), Houston (1997), Bernini *et al.* (1998), Thibault & Bonaccorsi (1999), Luniak *et al.* (2001), Danko *et al.* (2002), Tomialojć & Stawarczky (2003), Bezzel *et al.* (2005), Mihelič (2005), Cairo & Facoetti (2006), Feldner *et al.* (2006), Betleja *et al.* (2007), Maumary *et al.* (2007) |

## RESULTS AND DISCUSSION

### The ancient period (7th century BC to 5th century AD)

Relationship between crows and humans is known already from Ancient Egypt (Foufopoulos & Litinas, 2005). Crows were common along the Nile River and were as scavengers in regular contact with humans, although it is not known whether they also bred in human settlements. For the area of Slovenia and adjacent lands, ancient Greek (between 5th and 4th century BC) and Roman sources (between years 753 BC and AD 476) are much more important. Sources from both periods are reporting on regular occurrence of crows in urban areas (Aristoteles; Plinius). In archaeological investigations of ancient Roman settlements, bone remains of the Hooded Crows were found, and the species was found illustrated in wall paintings together with other characteristically synantropic species, *e.g.*, House/Italian Sparrow *(Passer domesticus/italiae)* (Jashemski & Meyer, 2002). Similar as the Raven *(Corvus corax),* it seems that the Crow was a common urban species in Southern Europe in ancient times (Vrezec *et al.*, 2009). The human attitude towards the species included positive and negative perceptions. On one hand the crow was connected to longevity, and on the other it was a symbol of widowhood (Foufopoulos & Litinas, 2005).

### 6th to 17th century

The Middle Ages are very poorly documented, considering technological development and natural science knowledge of the time. The oldest reliable written sources from the area of Southern Europe date back to 16th century, but interpretations of earlier times are somehow possible from numerous illustrations, frescos,

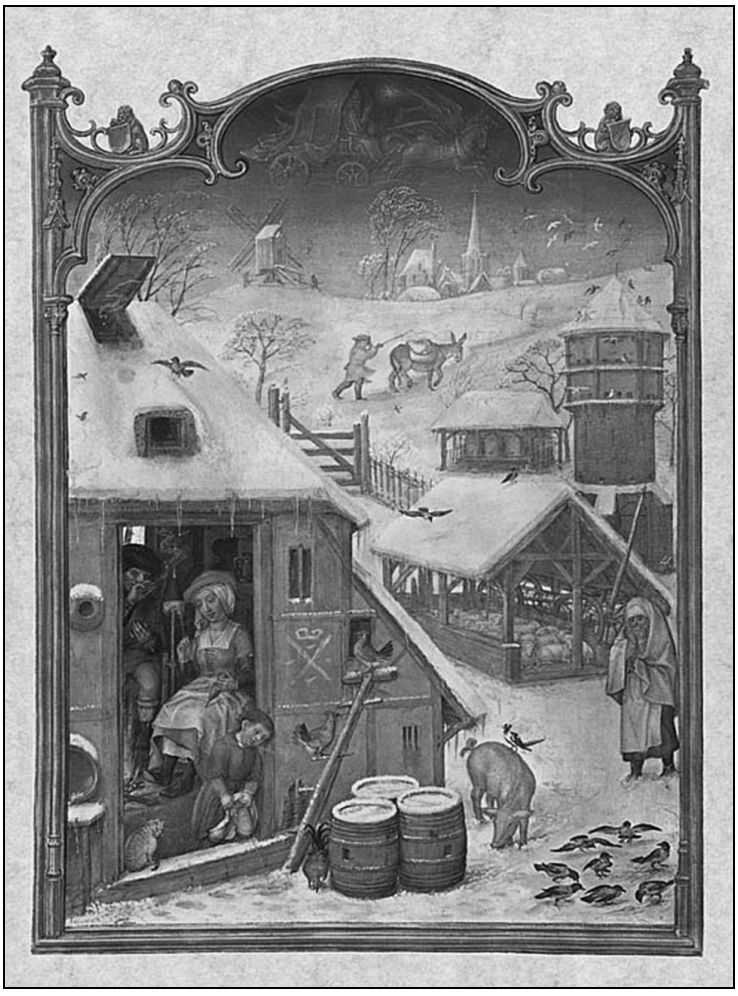

***Fig. 2: An example of miniature from Breviarium Grimani, a manuscript made in Belgium between years 1510 and 1520, is indicating regular occurrence of Hooded Crows in human settlements.***
***Sl. 2: Primer miniature iz rokopisa Breviarium Grimani, izdelanega v Belgiji med leti 1510 in 1520, nakazuje na redno pojavljanje sive vrane v naseljih.***

miniatures, reliefs, heraldic symbols etc. (Wiet *et al.*, 1975). From the territory of Slovenia, the image of the Crow is known from the coat of arms of Vransko, which originates from 13th century. The images of Crows can also be found in the Hrastovlje church frescos made in 1490 (Zadnikar, 1988), but these images are quite unclear. More accurate are images in miniatures of manuscripts. In the Belgian manuscript Breviarium Grimani, written between 1510 and 1520, it is clearly shown that Crows were following humans in the fields and settlements (Fig. 2) (Walther & Wolf, 2001).

In the late Middle Age and Renaissance periods, the Crows were common breeding birds in urban areas of Europe (Gesner, 1555; Aldrovandus, 1646; Jonston, 1650; Willoughby, 1676). Beside settlements the Crows were very common also on agricultural land, and large flocks frequently gathered at rubbish dumps, and at river and sea shores (Aldrovandus, 1646; Jonston, 1650). The human settlements in the Renaissance were in general attractive to scavenger birds, beside Crows also Ravens, Egyptian Vultures *(Neophron percnopterus)* and Black Kites *(Milvus migrans)* (Aldrovandus, 1646; Jonston, 1650). The last two species are nowadays absent from European cities, but the Raven and Crow are recolonizing urban areas (Houston, 1997; Vrezec *et al.*, 2009). It is documented that Carrion Crows increased greatly in England in the time of Henry VIII (1509–1547), and that crows had been extirpated for the following ten years at the least (Pennant, 1768). Otherwise, there are no reports on Crow extermination from other parts of Europe from this period.

### 18th century

In 18th century, the Crow was distributed over the whole Europe (Linnaeus, 1758). However, there were remarkable changes considering the species urban occurrence. In the published studies from 18th century, the Crow was no longer considered as an urban breeder, but as a common breeder of fields, meadows, forests and montane areas (Linnaeus, 1746; Kramer, 1756; Brisson, 1763; Pennant, 1768; Scopoli, 1769). Only in winter the birds aggregated in flocks which came near the settlements (Kramer, 1756; Scopoli, 1769; Buffon, 1788). The most probable cause for this change was an intensive human persecution of the corvid and raptor species, which for example drastically reduced also the Raven population in Europe (Vrezec *et al.*, 2009). The Crow remained a common species in Europe, but retreated from former breeding places in urban areas.

### 19th century

Similarly as in 18th century, the Crows were absent from the urban areas at the beginning of 19th century, but occurred there more frequently in winter time (Erjavec, 1870; Fritsch, 1870; Blasius *et al.*, 1905). The first urban colonisations were recorded at the end of the century (Brehm, 1879), also in Slovenia and adjacent countries (Reiser, 1925, 1939), but these colonisations were not as rapid and permanent as later ones at the end of 20th century. Although even naturalists in that time supported intensive extermination of raptorial pests, *i.e.,* the Raven (Vrezec *et al.*, 2009), at least the Hooded Crow was treated in a more positive manner. Despite the damage crows did from time to time on the fields, they were regarded as useful due to their habit of feeding on different pest insects (Erjavec, 1870; Gjurašin, 1899).

### 20th and 21st century

In 20th century, Crows rapidly colonised urban areas. The process started already at the end of 19th century (Houston, 1997). In Poland, for example, the colonisation started in 1930 in Warszawa, followed in Poznan in 1951, in Wroclaw in 1972, in Krakow in 1974 and in cities at the Baltic Sea shore in the 70.-ties (Tomialojć & Stawarczky, 2003). But the colonisation rate was not equal around Europe. In some countries, there was no urban population in the 70s *(e.g.,* Matvejev, 1976; Thibault & Bonaccorsi, 1999), and breeding densities of Crows today are still different between cities (Tab. 2). The last is probably due to different ecological conditions, *i.e.,* food availability, size of non-urban populations in the surrounding, intensity of prosecution etc. Compared to Middle Europe, densities in Southern and Northern Europe are lower, since the urban colonisation there is a fairly recent event (Tab. 2) (Vuorisalo *et al.*, 2003). In Slovenia, urban breeding Hooded Crows are nowadays known for the majority of cities, namely Nova Gorica, Kranj, Ljubljana, Domžale, Kočevje, Novo mesto, Celje, Ptuj, Slovenska Bistrica, Maribor, Murska Sobota, but locally still absent in some, *e.g.,* Žalec, Slovenj Gradec, Velenje, Slovenske Konjice (Vogrin, 2003; Mihelič, 2005; DOPPS, unpubl. data of New Ornithological Atlas of Slovenia for the period 2002–2009). However, according to the published observations from Ljubljana and some NE Slovenian cities, it can be concluded that rapid urban colonization of the Hooded Crow had happened relatively recently in Slovenia, starting probably not before the 80.-ties of 20th century (Sovinc, 1994; Vogrin, 2003). In general, further urban colonisation in Europe is expected to take place especially in Southern and Northern Europe since expected climatic changes are not going to drastically influence the Crow population in Europe (Huntley *et al.*, 2007).

***Tab. 2: Overview of breeding densities of Crows, Hooded** Corvus cornix **and Carrion Crow** C. corone**, in selected European cities.***
***Tab. 2: Pregled gnezditvenih gostot vran, sive** Corvus cornix **in črne vrane** C. corone **v izbranih evropskih mestih.***

| State | City | Searched area (ha) | Crow (sub)species | Density (pairs per 10 ha) | Source |
|---|---|---|---|---|---|
| Slovenia | Ljubljana* | 467 | *cornix* | 0.32-0.43 | Mihelič (2005) |
| Slovenia | Maribor | 118 | *cornix* | 0.17 | Vogrin (2003) |
| Slovenia | Celje | 99 | *cornix* | 0.15 | Vogrin (2003) |
| Slovenia | Ptuj | 46 | *cornix* | 0.22 | Vogrin (2003) |
| Slovenia | Slovenska Bistrica | 73 | *cornix* | 0.13 | Vogrin (2003) |
| Italy | Napoli | 11730 | *cornix* | 0.001 | Spadea (1995) |
| Italy | Roma | 36000 | *cornix* | 0.09 | Cignini & Zapparoli (1996) |
| Italy | Spezia | 5222 | *cornix* | 0.03 | Biagioni *et al.* (1996) |
| Italy | Pavia | 6286 | *cornix* | 0.16-0.48 | Bernini *et al.* (1998) |
| Italy | Bergamo | 3900 | *cornix* | 0.08-0.13 | Cairo & Facoetti (2004) |
| Germany | W Berlin | 48000 | *cornix* | 0.10-0.15 | Witt (1984) |
| Belgium | Bruxelles | 16178 | *corone* | 0.40-0.93 | Rabosee (1995) |
| Poland | Warszawa | 49400 | *cornix* | 0.20-0.30 | Luniak *et al.* (2001) |
| Poland | Gliwic | 13057 | *cornix* | 0.04-0.08 | Betleja *et al.* (2006) |
| Poland | Leszna | 3190 | *cornix* | 0.17-0.19 | Kuzniak (1996) |

* In Ljubljana only the area of city park Tivoli was surveyed and not the urban city centre.
* V Ljubljani je bil upoštevan samo predel mestnega parka Tivoli in ne urbano središče mesta.

## CONCLUSION

As an urban breeding bird, the Crow was known already in ancient times. Therefore, recent colonisations of the cities by the species across Europe are not due to the actual ecological or behavioural changes of this highly adaptable species. It is simply a recolonisation process of breeding areas abandoned in the past due to heavy human persecution. Although there is no historical data available to estimate population dynamic of the Crow, its urban presence could be used as an indicator of its past population status. Urban areas are suboptimal habitat of the Crow (Richner, 1989). In general, the species first disappears from suboptimal habitats when its population declines (Begon *et al.*, 2006). Most of the references included in this study quote that the Crow has been a common and abundant bird throughout the history. However, the species absence from urban areas, especially in 18th and 19th century (Fig. 3), indicate large population decline in this period, when also populations of other corvids, *e.g.*, the Raven, declined drastically (Glandt, 2008; Vrezec *et al.*, 2009). Even in winter time Crows were far less frequent in settlements during 18th and 19th century (Fig. 3). In 19th century more naturalist writers called against crow extermination, seeing the species as an efficient insect pest predator on agricultural land. Already at the end of 19th century, the recolonisation of urban areas began and is still continuing nowadays (Fig. 3). What contributed to the higher

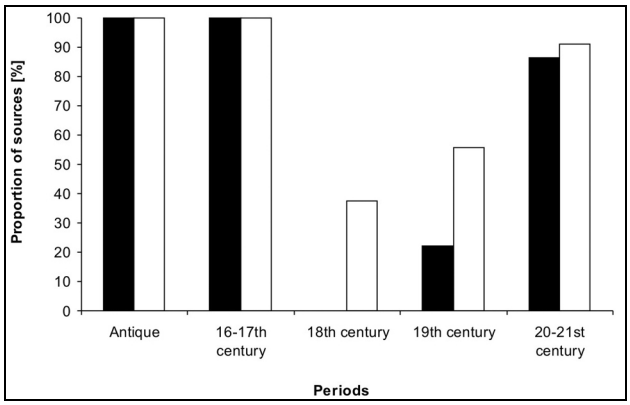


***Fig. 3: Status of Hooded and Carrion Crows in urban areas of Europe in different historical periods (the Middle Age period is not included due to the lack of relevant written sources). The frequency of species occurrence in breeding (black bar) and winter (non-breeding; white bar) season is estimated as a proportion of examined sources (see Table 1 for the list) per period.***
***Sl. 3: Status sive in črne vrane v urbanih predelih Evrope v različnih zgodovinskih obdobjih (obdobje srednjega veka ni vključeno zaradi pomanjkanja relevantnih pisnih virov). Pogostost pojavljanja vrste v obdobju gnezditve (črn stolpec) in prezimovanja (ko ni razmnoževanja; bel stolpec) je ocenjena skozi delež obravnavanih virov (glej Tabelo 1 za seznam) v posameznem obdobju.***

urban colonisation rate in the last decades is not only lower intensity of persecution but also other human influenced environmental factors; *e.g.*, increased food sources at rubbish dumps (Meyer *et al.*, 2003) and low populations of main crow predators, *i.e.,* Goshawk *(Accipiter gentilis)* and Peregrine Falcon *(Falco peregrinus).*

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# ZGODOVINSKI PREGLED POJAVLJANJA SIVE/ČRNE VRANE (*CORVUS CORNIX/CORONE*) V URBANIH OKOLJIH EVROPE S POUDARKOM NA SLOVENIJI

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*POVZETEK*

*Siva* (Corvus cornix) *in črna vrana* (Corvus corone) *sta bili zelo razširjeni evropski vrsti že v obdobju spodnjega pleistocena pred večjo človeško kolonizacijo. Gre za eno tistih avtohtonih vrst, ki so se uspele naseliti tudi v urbana in od človeka spremenjena okolja, še posebej intenzivno v zadnjem stoletju. Cilj pričujoče študije je bil ugotoviti spremembe statusa urbane populacije vrste v preteklosti znotraj petih zgodovinskih obdobij. V ta namen je avtor zbral in pregledal relevantne pisne vire o biologiji in ekologiji vrste za posamezna obdobja od antike pa do danes s posebnim poudarkom na dogajanju v Sloveniji. Iz virov je ugotavljal status in pogostost pojavljanja vrane v urbanih okoljih v gnezditvenem in zimskem obdobju ter odnos ljudi do vrste. Kot urbana gnezdilka je bila siva vrana poznana že v obdobju antike. Prav tako je bila vrsta v obdobju srednjega veka in renesanse pogosta gnezdilka v takratnih mestih skupaj z nekaterimi drugimi mrhovinarskimi pticami kot so krokar* (Corvus corax), *egiptovski jastreb* (Neophron percnopterus) *in črni škarnik* (Milvus migrans). *Glede na vire je bila vrana (siva in črna vrana) v Evropi splošno razširjena vrsta tudi v 18. stoletju, vendar pa so urbane populacije v tem obdobju izginile. Jate vran so se naseljem približevale le v zimskem času. Razlog za spremembo in populacijski upad je najverjetneje intenzivno preganjanje vran in ujed, ki so jih v 18. in še v 19. stoletju imeli za velike škodljivce. Šele konec 19. stoletja se je gledanje vsaj na sivo vrano spremenilo v pozitivno smer, saj so v ptici prepoznali koristnega pokončevalca škodljivega mrčesa na poljih. Tako so bile že konec 19. stoletja zabeležene prve rekolonizacije vran v urbanih okoljih po Evropi. Rekolonizacija se je nato nadaljevala še v 20. stoletju in poteka še danes, še posebej intenzivno na območju Srednje Evrope. V Sloveniji je naseljevanje sivih vran v mesta dokaj novodoben pojav, če odmislimo posamezne zabeležene poskuse konec 19. stoletja. Glede na objavljena opazovanja iz nekaterih slovenskih mest naj bi se pospešena kolonizacija urbanega okolja pri nas začela šele v 80-tih letih 20. stoletja. Glede na populacijske trende je pričakovati, da se bo rekolonizacija mest v prihodnosti intenzivneje nadaljevala na območju severne in južne Evrope. K povečani stopnji kolonizacije mest pa verjetno ni prispevalo le zmanjševanje preganjanja vrste, pač pa tudi drugi ekološki dejavniki, ki so posledica delovanja človeka, npr. večja dostopnost prehranskih virov (smetišča) in zaradi preganjanja v nedavni preteklosti nižje populacije glavnih vranjih plenilcev.*

**Ključne besede:** *Corvus cornix*, *Corvus corone*, urbana populacija, zgodovinska analiza, Evropa, Slovenija

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# NEW RECORDS OF NON-INDIGENOUS ALGAL SPECIES IN SLOVENIAN COASTAL WATERS

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## *ABSTRACT*

*New records of non-indigenous algal species in Slovenian coastal waters are presented. The red alga* Asparagopsis armata *Harvey (*Falkenbergia rufolanosa *phase) and the green alga* Codium fragile *subsp.* fragile *(Suringar) Hariot were collected in shallow waters in the period of the last five years. The author discusses the presence of other non-native algal species in the northern Adriatic and the importance of some vectors of introduction.*

**Key words:** non-indigenous algal species, Slovenian coastal waters, northern Adriatic Sea

# NUOVE SEGNALAZIONI DI SPECIE ALGALI NON-INDIGENE IN ACQUE COSTIERE SLOVENE

## *SINTESI*

*L'articolo riporta nuove segnalazioni di specie algali non-indigene in acque costiere slovene. L'alga rossa* Asparagopsis armata *Harvey (fase* Falkenbergia rufolanosa*) e l'alga verde* Codium fragile *subsp.* fragile *(Suringar) Hariot sono state raccolte in acque poco profonde negli ultimi cinque anni. L'autrice discute sulla presenza di altre specie alloctone nell'Adriatico settentrionale e l'importanza di alcuni vettori d'introduzione.*

**Parole chiave:** specie algali non-indigene, acque costiere slovene, Adriatico settentrionale

## INTRODUCTION

In the last three decades, at least 40 non-indigenous marine species have been recorded in the northern Adriatic Sea, among them 14 species of introduced macrophytes (reviews in Orlando-Bonaca, 2001 and Krmac, 2009; additional data in Curiel *et al.,* 2002). Different authors have documented the presence of four non-indigenous algal species in Slovenian waters.

In 1991, the tetrasporophyte *(Falkenbergia rufolanosa* phase) of the red alga *Asparagopsis armata* Harvey was recorded for the first time in Slovenian coastal waters and in the northern Adriatic (M. Richter, *pers. comm.*). Six years later, gametophyte plants were recorded in Croatian waters near Senj (M. Richter, *pers. comm.*). This species originates from Australia and/or New Zealand and it was introduced to the Mediterranean Sea unintentionally with oysters (Ribera & Boudouresque, 1995). The presence of the alga in Slovenian coastal waters was reported also by Battelli (2000).

In 1992, the presence of *Codium fragile* subsp. *fragile* (Suringar) Hariot (as *Codium fragile* subsp. *tomentosoides* (van Goor) P.C. Silva) was noticed for the first time by Munda (1992). The finding of the subspecies in Slovenian coastal waters was confirmed in the following years (Munda, 1993; Battelli & Vukovič 1995; Battelli, 1996, 2000). This green alga originates in the Pacific Ocean around Japan and it spread remotely either as an associated unintentional introduction attached to shellfish as oysters, attached to ships' hulls or as spores in ballast tanks. Ribera & Boudouresque (1995) reported that the presence of the subspecies in the Mediterranean Sea was firstly confirmed in French waters in 1950. Subsequently it appeared at both near and distant sites, with no apparent link to either the direction of the currents or the distance.

In 1995, the filamentous tetrasporophyte – *Trailliella* "pink cotton wool" phase of the red alga *Bonnemaisonia hamifera* Hariot was found in Slovenian coastal waters (M. Richter, *pers. comm.*). This species originates in the Pacific and was probably introduced with shellfish from Japan (Gollasch, 2006).

In 1998, the green alga *Ulva scandinavica* Bliding was recorded for the first time in Slovenian coastal waters and in the Adriatic Sea (Battelli & Tan, 1998). Before that, the species that originates from Sweden and Norway was recorded in the Mediterranean Sea only on the West and South coast of Italy (Battelli & Tan, 1998).

The aim of this paper is to provide new data about the presence of the introduced algae in Slovenian coastal waters. The current state of the non-indigenous algal species in the area is also discussed.

## MATERIAL AND METHODS

The Slovenian coastal sea covers the southern part of the Gulf of Trieste. It is a shallow semi-enclosed gulf with a maximum depth of ca. 33 m in waters off Piran. Its coastline is approximately 46.7 km long. The Slovenian coastal area is affected by freshwater inflows and local sources of pollution, mostly anthropogenic impacts such as intensive farming, sewage outfalls, and mariculture (Francé & Mozetič, 2006; Mozetič *et al.*, 2008; Grego *et al.*, 2009). Many activities such as urbanisation and massive tourism have modified the natural shoreline (Turk, 1999).

From 2006 to 2010, benthic macroalgae were sampled in the upper-infralittoral belt (depth range from 1 to 4 m) in at least 51 sites selected in order to assess the ecological status of macroalgal communities, as required by the European Water Framework Directive 2000/60/EC (WFD) (Orlando-Bonaca *et al.*, 2008; Orlando-Bonaca & Lipej, 2009). Additionally, macroalgae were sampled from the water surface down to 10 m of depth in order to characterize benthic habitat types (Lipej *et al.*, 2007, 2008). These studies were broadened in the last years, as required by the Marine Strategy Framework Directive 2008/56/ES (Orlando-Bonaca *et al.*, 2010a, 2010b).

Collected samples were placed in plastic bags and the material was transported to the Marine Biology Station of the National Institute of Biology for analysis. Species identification of macroalgae was carried out in the laboratory in accordance with Ribera *et al.* (1992), Gallardo *et al.* (1993), Battelli (1996), Gomez Garreta *et al.* (2001), and Bressan & Babbini (2003).

## RESULTS AND DISCUSSION

Two non-indigenous algal species were collected in Slovenian coastal waters in the past five years. Samples of *C. fragile* subsp. *fragile* were collected twice (Tab. 1). In summer 2006, a single thallus was found at 3 m of depth at the Cape of the Piran peninsula, during regular monitoring sampling (Orlando-Bonaca *et al.*, 2008). In 2007, 2008 and 2009, the alga was not present in any sample. In August 2010, the subspecies was found to be much more abundant (average density 4 thalli $m^{-2}$) in the same site, along a coastal segment 50 m long, in a depth range from 1 to 1.5 m. Various unidentified red filamentous algae were growing epiphytically on thalli (Figs.1, 2). The subspecies could be considered as established in this area; however, it is too early to evaluate its potentially damaging impact on the native algal associations.

***Tab. 1: Records of non-indigenous algal species in Slovenian coastal waters from the period of the last 5 years.***
***Tab. 1: Podatki o tujerodnih vrstah alg v slovenskih obalnih vodah iz obdobja zadnjih 5 let.***

| Species | Sampling site | Date | Depth (m) | Average density (thalli $m^{-2}$) |
|---|---|---|---|---|
| *Codium fragile* subsp. *fragile* | Cape Piran | 24.07.2006 | 3.0 | a single thallus |
| | Cape Piran | 25.08.2010 | 1.5 | 4 |
| *Asparagopsis armata* | Marina Izola | 26.06.2008 | 1.0 | 3 |
| | Cape Ronek | 02.09.2008 | 1.0 | 2 |

***Fig. 1:*** *Codium fragile* ***subsp.*** *fragile* ***in the summer 2010 at the Cape of the Piran peninsula. (Photo: L. Lipej)***
***Sl. 1:*** *Codium fragile* ***subsp.*** *fragile* ***poleti 2010 na rtu Piranskega polotoka. (Foto: L. Lipej)***

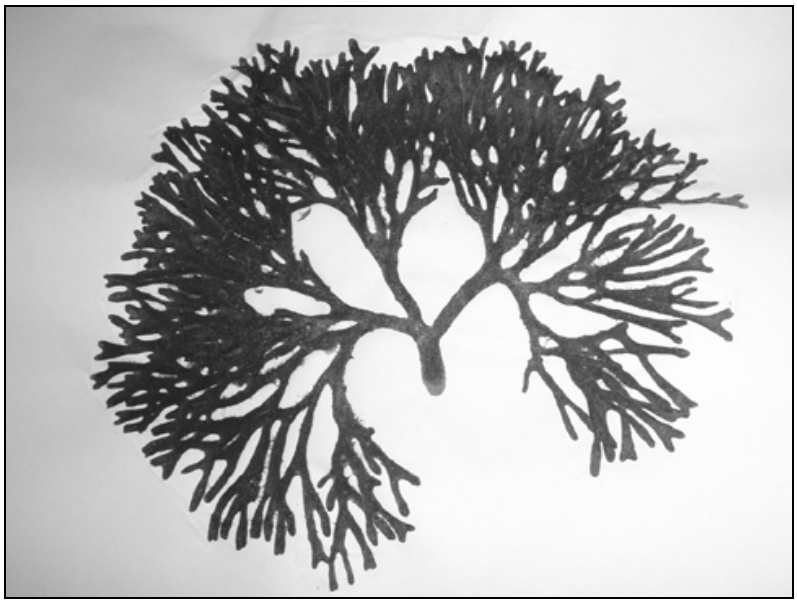

***Fig. 2: Herbarium specimen of*** *C. fragile* ***subsp.*** *fragile* ***collected in the summer 2010. (Photo: M. Orlando-Bonaca)***
***Sl. 2: Herbarijski primerek*** *C. fragile* ***subsp.*** *fragile****, nabran poleti 2010. (Foto: M. Orlando-Bonaca)***

In the Italian part of the Gulf of Trieste, *C. fragile* subsp. *fragile* was firstly reported by Godini & Avanzini (1988). Nowadays, the subspecies is commonly found in the northern area of the Gulf (Duino-Sistiana sampling sites) as reported in Falace (2000) and Ceschia *et al.* (2007). Scheibling and Gagnon (2006) provide clear evidence that competitive interactions with large, canopy-forming brown algae can limit the growth of *C. fragile* subsp. *fragile* on the Atlantic coast of Nova Scotia (Canada) but, once established, *Codium* meadows inhibit the re-establishment of native canopy-forming species. Molecular genetics analyses of widely distributed populations of subsp. *fragile* and of herbarium samples suggest that this is the only invasive form among the recognized subspecies of *C. fragile* (Provan *et al.*, 2008).

The tetrasporophyte of *A. armata* was collected in summer 2008 on limestone breakwater boulders of the Marina Izola (Tab. 1, Fig. 3). The alga was present along a coastal segment 20 m long. In the same year, some more thalli of the species were found at Cape Ronek on a sandstone terrace. The alga was not found during the last two years.

In 1978, *A. armata* was firstly reported for the Gulf of Trieste (Giaccone, 1978). Nowadays, the tetrasporophyte of the species is reported to be commonly found in Italian waters of the Gulf of Trieste (mostly in Miramare, Barcola and Aurisina sites) (Falace, 2000). However, the CIESM Atlas of Exotic Macrophytes in the Mediterranean Sea (2009) defines the species as "infrequent" for the Adriatic Sea.

*B. hamifera* has never been never found in any macroalgal sample collected by the Marine Biology Station. Falace *(pers. comm.)* has not found the species in the Italian part of the Gulf of Trieste. Anyhow, the CIESM Atlas of Exotic Macrophytes (2009) reports on one local record of the species in the Italian part of the Gulf (which is also the only record for the Adriatic Sea), but the bibliography is currently not available. It is therefore impossible to confirm the presence of this red alga in Slovenian waters.

The presence of *U. scandinavica* was not reconfirmed for Slovenian coastal waters. Moreover, it has never again been reported for the Mediterranean Sea after the publication of Battelli & Tan (1998). Some authors reported its presence on the Atlantic coasts of France, Portugal and Spain (Diaz-Tapia & Bárbara, 2005; Dizerbo & Herpe 2007; Araujo *et al.*, 2009). But according to AlgaeBase (Guiry & Guiry, 2010) and WoRMS (Appeltans *et al.*, 2010) registers, this name is currently regarded as a taxonomic synonym of *Ulva rigida* C. Agardh.

Although just two non-indigenous algal species appear nowadays to be established in Slovenian coastal waters, it is reasonable to expect the list to expand in the near future. Other non-indigenous algal species were found to be well established in the northern Adriatic, and they could easily reach the Slovenian Sea, both from Italian and Croatian waters. In the years from 1992 to 1994, three invasive algae, *Undaria pinnatifida* (Harvey) Suringar, *Sargassum muticum* (Yendo) Fensholt, and

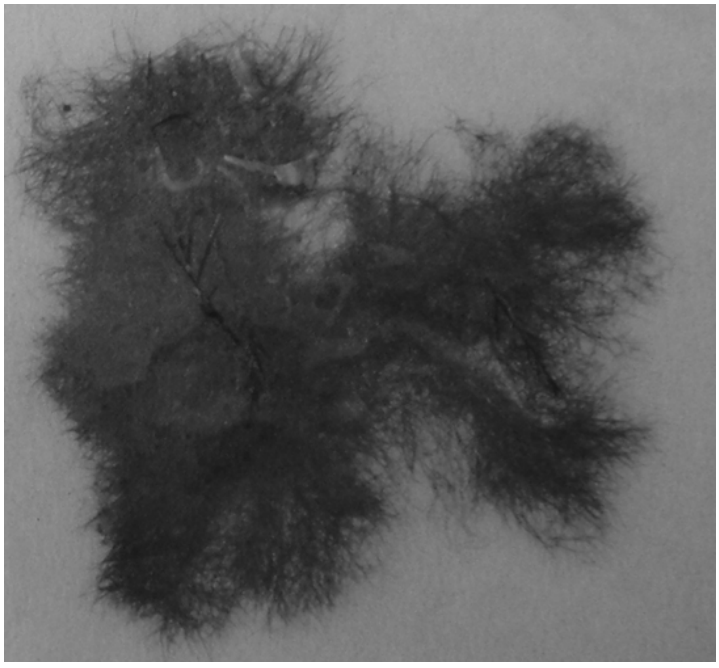

***Fig. 3: Herbarium specimen of** Asparagopsis armata **collected in the summer 2008. (Photo: M. Orlando-Bonaca)***
***Sl. 3: Herbarijski primerek** Asparagopsis armata, **nabran poleti 2008. (Foto: M. Orlando-Bonaca)***

*Antithamnion pectinatum* (Montagne) J.Brauner were recorded in the Venetian Lagoon (Curiel *et al.*, 1994, 1995, 1996, 1998). These seaweeds were introduced into European waters along with *Crassostrea gigas*, in the late 1960s (Critchley *et al.*, 1983; Rueness, 1989). They quickly colonized the hard substrata in the Venetian Lagoon, competing very well with indigenous species, due to their efficient reproduction mechanisms (Curiel *et al.*, 1998). In 1996, a brown alga from the genus *Sorocarpus* was first recorded in the Mediterranean Sea, again in the Venetian Lagoon (Curiel *et al.*, 1999). Some years later, Curiel *et al.* (2002) reported the finding of *Polysiphonia morrowii* Harvey, and *Desmarestia willii* Reinch (as *Desmarestia confervoides* (Bory de Saint-Vincent) M. E. Ramírez & A. F. Peters) in the same area. Moreover, in 2000 *Lomentaria hakodatensis* Yendo, known from China, Japan and Korea, was found in the Venetian Lagoon (Curiel *et al.*, 2006). The last record concerns *Acrothamnion preissii* (Sonder) E.M. Wollaston, originating from Western Australia, that was collected in July 2007 in the Marano and Grado Lagoon (Falace *et al.*, 2009).

Other three invasive algal species are considered to be established in the Croatian part of the northern Adriatic Sea. The tropical alga *Caulerpa taxifolia* (M. Vahl) C. Agardh, accidentally introduced from the Oceanographic Museum in Monaco into the natural environment (Meinesz & Hesse, 1991), was found in the Adriatic Sea in Stari Grad Bay (Hvar Island, Croatia) and in Malinska (Krk Island) in 1994, and in the Barbat Channel (Dolin Island) in 1996 (Žuljević & Antolić, 1998). The alga was only partially eradicated from Malinska (Žuljević & Antolić, 1998). *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, originating from South-western Australia, is currently considered more dangerous for natural habitats of the northern Adriatic. The first record of the species in the Adriatic dates from 2000 at the Pakleni Islands (Žuljević *et al.*, 2003). Nowadays, more than 60 affected locations (also in the northern Adriatic) were recorded, with the species changing native macroalgal populations (Despalatović *et al.*, 2008). The third invasive species present in Croatian North Adriatic waters is the red filamentous alga *Womersleyella setacea* (Hollenberg) R.E. Norris. The seaweed has Indo-Pacific-Carribean origin and was recorded for the first time in the Rijeka Bay in 1997 (Battelli & Arko Pijevac, 2005). Since then, the species has frequently been found in at least 50 Adriatic locations, where its dense monospecific turfs on rocky bottoms are covering native algal assemblages (Despalatović *et al.*, 2008).

Nowadays it is well known that marine non-indigenous species are mostly transported intentionally and/or unintentionally for aquaculture purposes, or unintentionally with marine traffic (transport of organisms in ballast waters, sediments in ballast tanks and hull fouling) (Gollasch & Leppäkoski, 1999). Krmac (2009) reported that ballast waters that are released in the Port of Koper mostly originate from Porto Marghera (Venetian Lagoon) where vessels unload the cargo and introduce ballast waters. Subsequently, water from their ballast tanks is released into the Koper Bay when they reload. The possibility of new non-native species introduction into Slovenian waters is therefore still high, since the Venetian Lagoon is considered to be rich in invasive species. From studies concerning the tracking of the invasive species spread, underlying the accurate identification of cryptic taxa, it is evident that the number of taxonomic units involved in bio-invasion is currently underestimated (Provan *et al.*, 2008). As the future of the introduced species is unpredictable, it would be very useful to enforce the international collaboration in the Adriatic, and to constantly update the global data bank on introduced species and receptive habitats.

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This paper is dedicated to the memory of our wonderful colleague and friend Žiga Dobrajc, who recently tragically passed away.

# NOVI ZAPISI O TUJERODNIH VRSTAH ALG V SLOVENSKIH OBALNIH VODAH

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*POVZETEK*

*Avtorica podaja pregled novih podatkov o tujerodnih vrstah alg v slovenskih obalnih vodah. Rdeča alga* Asparagopsis armata *Harvey (faza* Falkenbergia rufolanosa*) in zelena alga* Codium fragile *subsp.* fragile *(Suringar) Hariot sta bili v zadnjih petih letih opaženi in nabrani v plitvem morju. Za zdaj sta to edini tujerodni algi, ki sta ustaljeni v slovenskem morju. Avtorica nadalje razpravlja o navzočnosti drugih vrst tujerodnih alg v Severnem Jadranu in o načinih vnosa. Tujerodne vrste bi lahko v slovensko morje prispele iz Beneške lagune, kjer so doslej potrdili navzočnost vsaj 8 vrst tujerodnih alg. Prav tako so 3 druge vrste alg že prisotne ob hrvaški obali v Severnem Jadranu in jih lahko zato upravičeno pričakujemo tudi v slovenskem delu Jadrana.*

**Ključne besede:** tujerodne vrste alg, slovenske obalne vode, Severni Jadran

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# THE NORTHERNMOST RECORD OF THE BRACHYURAN *HERBSTIA CONDYLIATA* (FABRICIUS, 1787) AND ITS DISTRIBUTION IN THE ADRIATIC SEA (DECAPODA, BRACHYURA, EPIALTIDAE)

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## *ABSTRACT*

*A less known decapod species* Herbstia condyliata *(Fabricius, 1787) has been recorded for the very first time in waters off the Slovenian coast, which is the northernmost locality for this species in the Adriatic Sea. The species is considered rare in the eastern Mediterranean; however, it is apparently common in the Adriatic Sea, where it is distributed from southern Dalmatia to the Gulf of Trieste.*

**Key words:** *Herbstia condyliata,* distribution, Decapoda, Gulf of Trieste, Adriatic Sea

# RITROVAMENTO PIÙ A NORD DEL GRANCHIO *HERBSTIA CONDYLIATA* (FABRICIUS, 1787) E LA SUA DISTRIBUZIONE NEL MARE ADRIATICO (DECAPODA, BRACHYURA, EPIALTIDAE)

*SINTESI*

*Una specie meno nota di crostacei decapodi,* Herbstia condyliata *(Fabricius, 1787), è stata trovata per la prima volta nelle acque al largo della costa slovena, il che corrisponde alla località più settentrionale per questa specie nel mare Adriatico. La specie è considerata rara nel Mediterraneo orientale, per quanto la sua presenza risulti apparentemente comune nel mare Adriatico, dove la si trova dalla Dalmazia meridionale al Golfo di Trieste.*

**Parole chiave:** *Herbstia condyliata,* distribuzione, Decapoda, Golfo di Trieste, mare Adriatico

## INTRODUCTION

The decapod fauna of the northernmost part of the Adriatic Sea, *i.e.* Slovenia and the Gulf of Trieste, was not given any particular scientific attention in the past in comparison with other Adriatic areas. Only a single specific report on the subject is available, published by Manning & Števčić (1982), together with an overview of the northern Adriatic fauna (Matjašič *et al.*, 1975; Manning & Števčić, 1982). Therefore, discoveries of new decapod species are to be expected.

We report on the recent findings of the brachyuran *Herbstia condyliata* (Fabricius, 1787) (Fig. 1), previously not known in the area of the Gulf of Trieste, at least not in terms of published scientific issues. In general, a rather scarce number of published records is known from the eastern Mediterranean, although the species does not seem to be rare in the western part (Lewinsohn & Holthuis, 1986). In the Adriatic Sea, the species was supposed to be very rare (Števčić, 1990), similar as in other adjacent areas of the eastern Mediterranean (*e.g.,* Koukouras *et al.*, 1992; Corsini & Kondilatos, 2006). However, in later supplements of the Adriatic decapod fauna list Števčić (2002) claims that *H. condyliata* is more common than previously supposed, but a comprehensive work on species distribution in the Adriatic Sea has not been published yet.

In this study we aimed to collect all published and available unpublished data about *H. condyliata* occurrence in the Adriatic Sea and report on the recent findings of the northernmost occurrence of the species in the area.

## MATERIAL AND METHODS

We have reviewed published references on occurrence of *H. condyliata* in the area of the Adriatic Sea. We included also data on species occurrence obtained by systematic samplings of crabs under the stones in infralitoral, data on by-catch by trawlers in shallow waters, data of marine biologist field work findings and occasional observations by marine photographers. Only a few specimens were preserved, and the specimen from Slovenia was delivered to the Piran Aquarium, where it was still alive at the time of the final version of the manuscript. The species was identified according to Falciai & Minervini (1992) and d'Udekem d'Acoz (2003). The biometric parameters of the above mentioned specimen and additional 17 specimens from Croatia such as carapax, cheliped, chela, dactylus, merus and carpus were measured to the nearest 0.1 mm (Tab. 1).

***Tab. 1: Biometric data on 18 specimens of** Herbstia condyliata **in the Adriatic Sea (median and interval between minimum and maximum are given in brackets; in milimeters).***
***Tab. 1: Biometrični podatki za 18 primerkov vrste** Herbstia condyliata **iz Jadranskega morja (median in interval med minimumom in maksimumom sta podana v oklepajih; v milimetrih).***

| Locus | Sex | N | Carapace length | Carapace width | Right cheliped total length | Right chela length | Upper margin of cheliped propodius | Dactylus | Carpus | Merus |
|---|---|---|---|---|---|---|---|---|---|---|
| Piran (Slovenia) | M | 1 | 55.0 | 42.0 | 93.0 | 47.0 | 36.0 | 21.0 | 13.0 | 33.0 |
| Krk (Croatia) | M | 3 | 16.3 (13.0-17.4) | 11.1 (8.9-12.8) | 14.7 (11.6-16.3) | 6.6 (4.8-7.1) | 4.2 (3.0-4.5) | 2.9 (2.4-3.3) | 2.5 (2.2-3.2) | 5.6 (4.9-6.0) |
| Iž (Croatia) | M | 6 | 24.0 (20.9-39.0) | 18.0 (14.4-31.6) | 26.4 (17.0-57.2) | 11.6 (8.0-27.3) | 6.8 (5.3-17.9) | 5.2 (3.8-11.6) | 3.7 (3.0-8.1) | 9.7 (6.2-21.1) |
| Korčula (Croatia) | M | 4 | 19.8 (14.4-38.0) | 14.8 (9.8-31.4) | 16.2 (12.9-32.9) | 6.7 (5.8-15.5) | 3.9 (3.4-10.2) | 3.0 (2.6-6.8) | 2.5 (2.1-4.9) | 5.5 (4.6-12.6) |
| **Total males** | | 14 | 22.4 (13.0-55.0) | 16.4 (8.9-42.0) | 20.5 (11.6-93.0) | 9.0 (4.8-47.0) | 5.3 (3.0-36.0) | 3.9 (2.4-21.0) | 3.1 (2.1-13.0) | 7.5 (4.6-33.0) |
| Krk (Croatia) | F | 3 | 24.1 (9.4-25.3) | 18.1 (6.0-19.1) | 22.8 (21.8-23.8) | 10.1 (10.1-10.2) | 6.1 (5.9-6.3) | 4.6 (4.4-4.8) | 3.2 (3.2-3.2) | 8.8 (8.6-9.0) |
| Iž (Croatia) | F | 1 | 29.5 | 23.1 | 28.5 | 12.2 | 7.1 | 5.3 | 3.9 | 10.9 |
| **Total females** | | 4 | 24.7 (9.4-29.5) | 18.6 (6.0-23.1) | 23.8 (21.8-28.5) | 10.2 (10.1-12.2) | 6.3 (5.9-7.1) | 4.8 (4.4-5.3) | 3.2 (3.2-3.9) | 9.0 (8.6-10.9) |

## RESULTS AND DISCUSSION

On 23 May 2009, a specimen of *H. condyliata* was photographed in the protected area Nature monument Cape Madonna (Piran) during night dive (Fig. 2). On 12 May 2010, another specimen was captured by a trawler off the northern coast of Piran (Slovenia) as by-catch. These are the first published records of the species in the Slovenian coastal sea and probably also in the whole Gulf of Trieste. The specimen was caught in the area of rocky bottom characterized by the precoraligenous stage of the coralligenous biocoenosis. Such habitat type offers plenty of cavities and cracks between rocks, thus providing shelter for *H. condyliata*. Although species size varies greatly according to data collected from different parts of the Adriatic Sea (Tab. 1), the specimen caught in Slovenia is one of the largest of its species even compared to other literature data (Pesta, 1918; Falciai & Minervini, 1992; d'Udekem d'Acoz, 2003; Corsini & Kondilatos, 2006). In days following 12 May 2010, many specimens were caught in the very same area off the northern Piran coast, but not preserved.

The presence of *H. condyliata* in the Adriatic Sea was confirmed already in the beginning of 20$^{th}$ century, but only for the South Dalmatian islands of Korčula, Vis and Hvar (Stossich, 1880; Pesta, 1918). According to collected data, the species is distributed along the whole eastern coast from south Dalmatia to the Gulf of Trieste (Fig. 3). It is found at rocky bottom in the coralligenous biocoenosis (Corsini & Kondilatos, 2006; T. Turk, *in litt.*, *unpubl. data*) or sandy bottom with rocks, marine caves and also in *Posidonia oceanica* beds (Garcia-Raso, 1990). It was up to date recorded also in the submarine cave near Vrbnik (the island of Krk) in the Kvarner archipelago (Arko-Pijevac *et al.,* 2001) and in the anchialine cave Živa voda on the island of Hvar in the middle Adriatic Sea (Novosel *et al.*, 2007).

Therefore, it is probably not present along the western Adriatic coast, with the exception of Venice (Ševčić, 1990), where sandy bottom predominates. However, future studies are needed to reveal ecological characteristics and distribution limits of this poorly studied species.

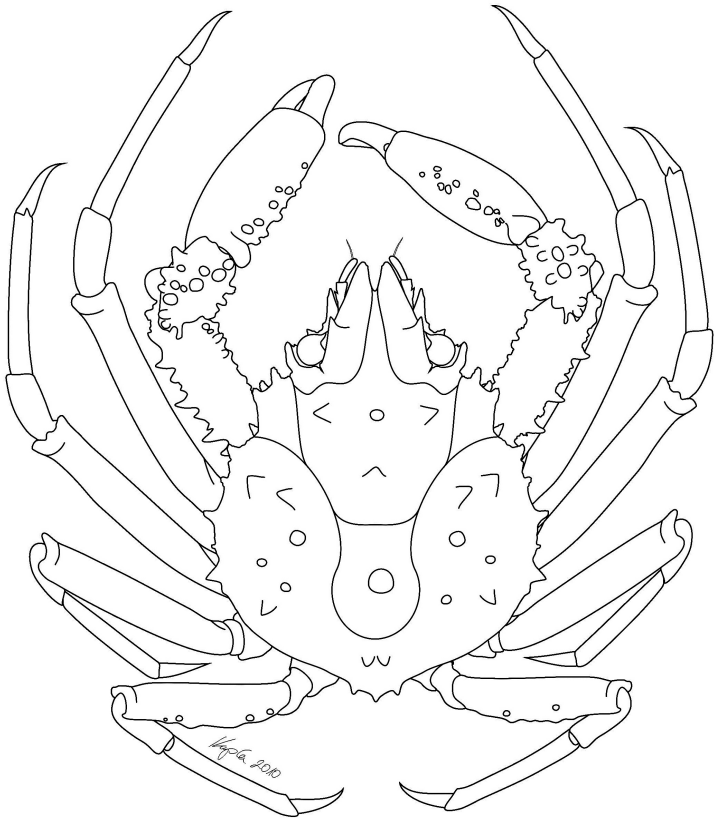

***Fig. 1/Sl. 1:*** *Herbstia condyliata* ***(Fabricius, 1787). (Drawing/Risba: A. Kapla)***

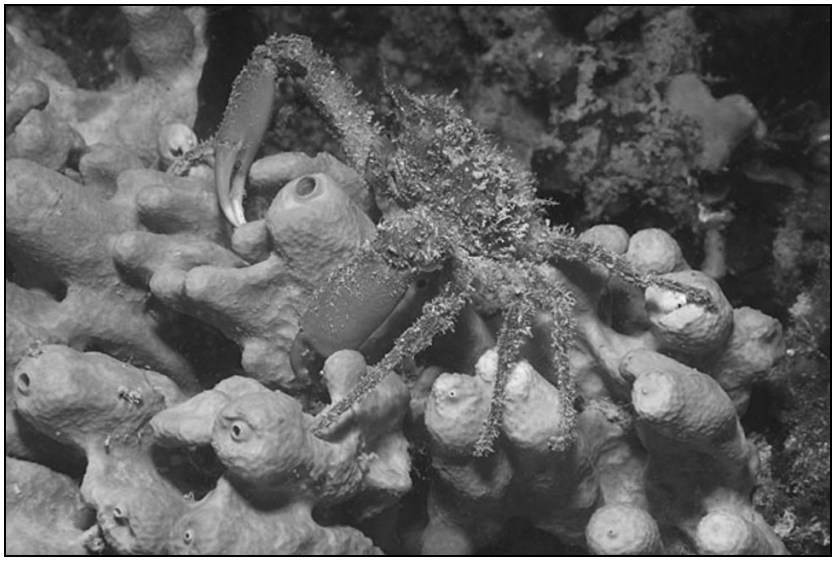

***Fig. 2: A specimen of** H. condyliata **photographed in its natural habitat at the nature monument Cape Madonna in Piran. (Photo: B. Furlan)***
***Sl. 2: Primerek vrste** H. condyliata**, fotografiran v njegovem naravnem habitatu pri naravnem spomeniku Rt Madona v Piranu. (Foto: B. Furlan)***

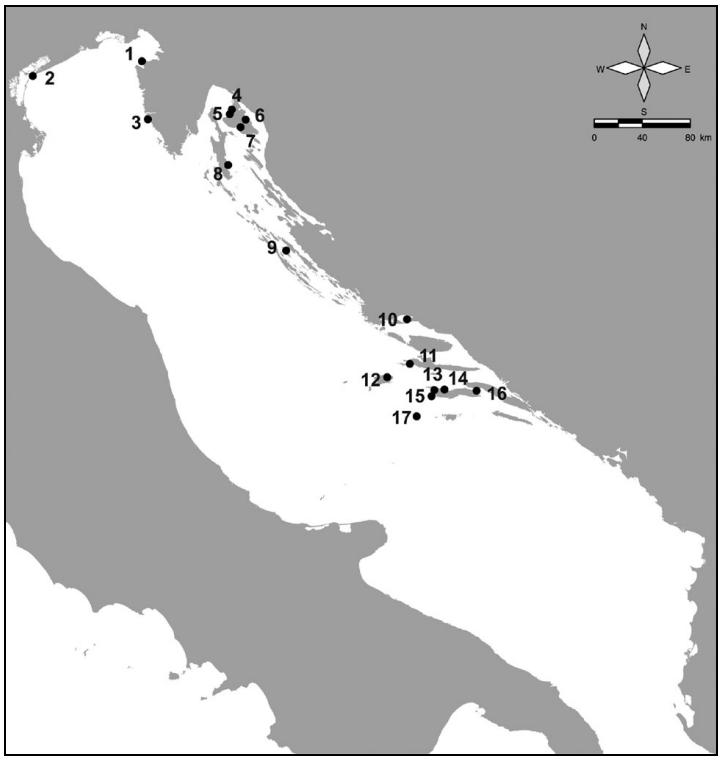


***Fig. 3: Distribution of** H. condyliata **along Adriatic Sea coast. Legend: 1-Piran, 2-Venice, 3-Rovinj, 4-Krk/Njivice, 5-Krk/Malinska, 6-Krk/Vrbnik, 7-Krk/Punat, 8-Cres/Čutin, 9-Veli Iž, 10-Split, 11-Hvar, 12-Vis/Vis, 13-Korčula/ Prigradica, 14-Korčula/Vela Luka, 15-Korčula/Trstenik, 16-Korčula/Korčula and 17-Sušac.***
***Sl. 3: Razširjenost vrste** H. condyliata **ob Jadranski obali. Legenda: 1-Piran, 2-Benetke, 3-Rovinj, 4-Krk/Njivice, 5-Krk/Malinska, 6-Krk/Vrbnik, 7-Krk/Punat, 8-Cres/Čutin, 9-Veli Iž, 10-Split, 11-Hvar, 12-Vis/Vis, 13-Korčula/ Prigradica, 14-Korčula/Vela Luka, 15-Korčula/Trstenik, 16-Korčula/Korčula in 17-Sušac.***

Although *H. condyliata* is supposed to be rare in the eastern Mediterranean and just occasionally found in low numbers (Koukouras & Kattoulas, 1975; Lewinsohn & Holthuis, 1986; Koukouras *et al.,* 1992; Kocatas *et al.,* 2004; Corsini & Kondilatos, 2006), it seems to be more common along the eastern Adriatic coast (Arko-Pijevac *et al.,* 2001; Ševčić, 2002; Novosel *et al.*, 2007; see Fig. 3).

To our opinion, *H. condyliata* is in general a common species in the Adriatic Sea although only locally abundant. The first sighting of this species in the Slovenian coastal sea was obtained by the means of SCUBA diving during night time, when these crabs are active. This case proves the suitability of diving techniques, which could provide new data on rare or less known species in otherwise inaccessible habitats for standard (destructive) fishing gears. At the same time, it justifies the urge for the establishment of a network of different groups who are somehow dealing with the biodiversity of the marine environment such as scientists, conservators, fishermen, divers, underwater photographers and others.

**ACKNOWLEGMENTS**

We would like to take this opportunity to express our thanks to our colleague, Dr. Tom Turk, who provided us with his data on the occurrence of the investigated species in the Adriatic Sea. Special thanks goes to Mr. Andrej Kapla for his exscellent drawing of the specimen.

# ZAPIS O NAJSEVERNEJŠEM POJAVLJANJU RAKOVICE *HERBSTIA CONDYLIATA* (FABRICIUS, 1787) IN RAZŠIRJENOST TE VRSTE V JADRANSKEM MORJU (DECAPODA, BRACHYURA, EPIALTIDAE)

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*POVZETEK*

*Manj znana rakovica* Herbstia condyliata *je bila prvič zabeležena v slovenskem delu Jadranskega morja, kar je obenem tudi njena najsevernejša lokaliteta v Jadranskem morju. Čeprav naj bi bila ta vrsta redka v vzhodnem Sredozemlju, kaže, da je v Jadranskem morju razmeroma običajna in jo najdemo od južne Dalmacije pa vse do Tržaškega zaliva.*

**Ključne besede:** *Herbstia condyliata,* razširjenost, Decapoda, Tržaški zaliv, Jadransko morje

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# FIRST RECORD OF THE DOLPHIN-FISH JUVENILES, *CORYPHAENA HIPPURUS* (LINNAEUS, 1758), IN THE EASTERN ADRIATIC SEA

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## *ABSTRACT*

*Two juvenile specimens of* Coryphaena hippurus *have been found in the Adriatic for the first time. Prior to this, larval stages were also encountered in the Adriatic which, along with findings of the juveniles, might indicate that* C. hippurus *reproduces in these waters. In the last few years, records of larval and juvenile stages of the species that were previously rare or relatively rare in the area became more common.*

**Key words:** *Coryphaena hippurus*, juvenile fish, Adriatic Sea

# PRIMA SEGNALAZIONE DI STADI GIOVANILI DI LAMPUGA, *CORYPHAENA HIPPURUS* (LINNAEUS, 1758), IN ADRIATICO ORIENTALE

*SINTESI*

*Due esemplari giovanili di* Coryphaena hippurus *sono stati trovati per la prima volta nel mare Adriatico. Prima di tale cattura, anche stadi larvali sono stati rinvenuti nel mare Adriatico il che, assieme al ritrovo di stadi giovanili, potrebbe indicare che* C. hippurus *si riproduce in tali acque. Negli ultimi anni, catture di stadi larvali e giovanili di specie in precedenza considerate rare o relativamente rare nell'area, sono diventate più frequenti.*

**Parole chiave:** *Coryphaena hippurus*, stadio giovanile, mare Adriatico

## INTRODUCTION

The dolphin-fish, *Coryphaena hippurus* (Linnaeus, 1758) is an epipelagic cosmopolitan species inhabiting open waters but also approaching the coast. It is a highly migratory species distributed throughout tropical and subtropical waters including the Atlantic, Pacific and Indian Oceans (Palko *et al.*, 1982). It is also distributed in the Mediterranean Sea, but is more abundant in its western part where it occurs seasonally from May-June to December (Massuti & Morales-Nin, 1997). This species is also present in the Adriatic Sea where it was considered relatively rare (Jardas, 1996). However, in the recent years it became more common and during the summer months it appears in significant abundance. This suggests that it should be treated as a common species at least seasonally, especially in the southern part of the Adriatic (Dulčić & Lipej, 2002). Although *C. hippurus* is not a target species of commercial fisheries in the Adriatic, probably because of its seasonality and relatively low market price, recreational fishermen take advantage of its presence in the summer months.

There is a great scarcity of published information on biology and ecology of *C. hippurus* in the Adriatic. In fact, except for one paper about the presence of the larval stages of *C. hippurus* in the Adriatic by Dulčić (1999), no other data is available. The aim of this paper is to present the first records of the juvenile stages of this species in the Adriatic with its biometric and meristic characteristics, and to improve knowledge about this species in the area.

## MATERIAL AND METHODS

One *Coryphaena hippurus* juvenile was found swimming inside a floating bucket in the open sea in the Adriatic on 29 July 2008, about 12 miles south of the Biševo Island (Fig. 1, location 1). The other specimen was found free swimming close to the sea surface on 5 July 2003 near the south-east side of the Biševo Island (Veli Žardin cove) (Fig. 1, location 2) and was caught by a hand net. Both specimens were identified according to the taxonomic key by Jardas (1996), preserved in 4% formalin and deposited in the ichthyological collection of the Institute of Oceanography and Fisheries (IOR-313).

Total and standard length and biometric measurements of the specimens were measured to the nearest mm, while the weight of the fish to the nearest 0.01 g. Meristic characteristics of dorsal, anal, pectoral and caudal fin rays were also taken.

## RESULTS AND DISCUSSION

Biometric and meristic data of the specimens of *Coryphaena hippurus* are presented in Table 1 and are in agreement with those provided by Palko *et al.* (1982).

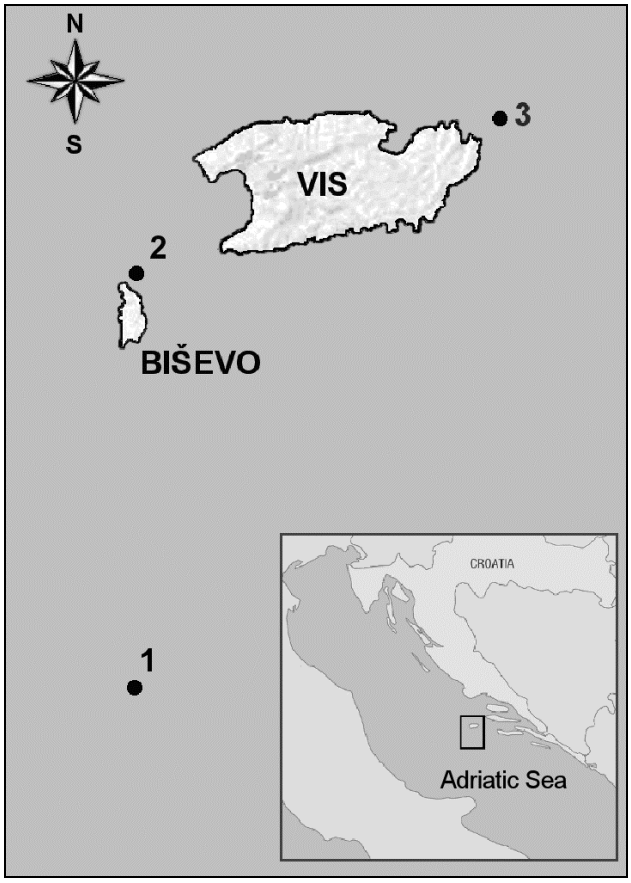


***Fig. 1: Locations of the occurence of early life stages of** Coryphaena hippurus **in the Adriatic Sea. See text for details.***
***Sl. 1: Lokacije pojavljanj zgodnji življenjskih faz** Coryphaena hippurus **v Jadranskem morju. Za podrobnosti glej besedilo.***

The larger specimen (Fig. 2), caught in 2008, was 13.0 cm TL and weighted 12.22 g, while the smaller specimen (Fig. 2), caught in 2003, was 4.7 cm TL and weighted 0.75 g. It is interesting to note that the larger specimen was found swimming inside a floating bucket. This can be explained by the fact that these fish can often be associated with various floating objects. It is possible that this individual was probably swimming under the object, but was somehow trapped inside.

The body of both juvenile *C. hippurus* was elongated and compressed and the height of the head was not as pronounced as in the adult fish. The colour of the smaller specimen was brown, with 15-16 vertical bars across the flanks, while the colour of the larger specimen was dark gray, with silvery flanks. Along the flanks, close to the dorsal fin of the larger specimen, 14 white dots were noticed, but they were visible only while the fish was still fresh. The dots became unnoticeable after the fish was placed in formalin. Pelvic, dorsal and anal

***Tab. 1: Morphometric and meristic properties of*** *Coryphaena hippurus* ***juveniles. All measurements are given in centimeters.***
***Tab. 1: Morfometrični in meristični podatki mladostnih primerkov*** *Coryphaena hippurus*. ***Vse meritve so podane v centimetrih.***

| **Morphometric parameter** | *C. hippurus* 1 | *C. hippurus* 2 |
|---|---|---|
| Total length | 13.0 | 4.7 |
| Standard length | 11.1 | 3.9 |
| Fork length | 11.5 | 4.5 |
| Predorsal length | 1.7 | 0.8 |
| Preanal length | 5.9 | 2.2 |
| Preventral length | 2.7 | 1.1 |
| Prepectoral length | 2.5 | 1.0 |
| Dorsal fin length | 8.8 | 2.9 |
| Anal fin length | 4.2 | 1.5 |
| Pectoral fin length | 1.6 | 0.7 |
| Ventral fin length | 2.0 | 1.0 |
| Caudal fin length | 2.2 | 0.8 |
| Maximum body depth | 2.1 | 0.9 |
| Minimum body depth | 0.6 | 0.3 |
| Head length | 2.7 | 1.1 |
| Ocular diameter | 0.7 | 0.4 |
| Interorbital width | 0.8 | 0.3 |
| Preorbital length | 0.7 | 0.2 |
| **Meristic parameter** | | |
| Dorsal fin rays | Damaged | 50 |
| Anal fin rays | Damaged | 23 |
| Pectoral fin rays | 20 | 21 |
| Ventral fin rays | I + 5 | I + 5 |
| Caudal fin rays | Damaged | 20 |


***Fig. 2: Juvenile specimens of*** *C. hippurus* ***from the Adriatic Sea.***
***Sl. 2: Mladostna primerka*** *C. hippurus* ***iz Jadranskega morja.***

fins were black, while the pectoral ones were white. Tips of the caudal fin were white in both specimens, while the rest of the fin was brown.

The presence of the juvenile stages of *C. hippurus* in the Adriatic Sea is of particular interest, since it indicates a possibility that this species reproduces in the Adriatic. This presumption can also be supported by the findings of larvae by Dulčić (1999). However, the possibility that fertilized eggs and larval stages of this pelagic species have been drifted to the Vis and Biševo area from southern areas by the sea currents cannot be excluded. This hypothesis could be explained by the Adriatic ingressions, a well documented phenomenon of intensified influx of Ionian waters into the Adriatic Sea (see Grbec *et al.*, 1998). Moreover, it seems that ingressions might represent a suitable explanation for unusual presence of various thermophillic fishes in the Adriatic Sea, but such conclusion should be supported by future research.

Both juvenile specimens were found near the Biševo Island in July, while Dulčić (1999) found two *C. hippurus* larvae (4.75 and 4.95 mm SL) in the vicinity of the Vis Island in August (Fig. 1, location 3). This suggests that the actual spawning takes place in the period from June to August which is corroborated by the fact that the period of spawning in the western Mediterranean is from June to July (Massuti & Morales-Nin, 1997).

Since *C. hippurus* is exploited mostly in the western and central part of the Mediterranean, information concerning biology and distribution of this species are limited to that area. This species is target of offshore local fishermen around the Balearic Islands, Tunisia, Sicily and the Maltese Islands where it seasonally occurs in great abundance (Castriota *et al*., 2007). The first record of larval stages of *C. hippurus* in the Mediterranean Sea was reported by Alemany & Massuti (1998) for the area off the Balearic Islands, but there is still a great scarcity of information about the presence and distribution of this species in the eastern Mediterranean.

In the last few years, records of larval and juvenile stages of the species that were previously rare or relatively rare in the Adriatic Sea became more common. Findings of early life stages of species like *Balistes carolinensis, Trachinotus ovatus* and *Trachipterus trachypterus* could be a consequence of new climatological and oceanographical conditions in the Adriatic as well as in the Mediterranean Sea. These new conditions are probably a key for the increased abundance of *C. hippurus* in the Adriatic Sea in the recent years. Prior to these new findings, including larvae found by Dulčić (1999), there were no findings of such early life stages of this species in the Adriatic Sea, therefore, it is reasonable to conclude that its reproduction in the Adriatic is a recent adaptation to a new and changing environment.

**ACKNOWLEDGEMENT**

The authors would like to thank Mr. Damir Roje for providing one of the specimens and to Mr. Robert Grgicevic for additional help.

# PRVI PODATKI O MLADOSTNIH PRIMERKIH DELFINKE *CORYPHAENA HIPPURUS* (LINNAEUS, 1758) V VZHODNEM JADRANSKEM MORJU

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*POVZETEK*

*Prvič sta bila v Jadranskem morju najdena dva mladostna primerka vrste* Coryphaena hippurus. *Dejstvo, da so bile pred tem v Jadranu opažene larve te vrste, skupaj z najdbo mladostnih primerkov nakazuje na možnost, da se* C. hippurus *razmnožuje v teh vodah. V zadnjih nekaj letih so podatki o larvah in mladostnih primerkih vrste, ki so bili pred tem redki oz. relativno redki, vse pogostejši.*

**Ključne besede:** *Coryphaena hippurus,* mladostni primerki, Jadransko morje

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# FIRST RECORD OF THE DUSKY SPINEFOOT *SIGANUS LURIDUS* (RÜPPELL, 1828) IN THE ADRIATIC SEA

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## *ABSTRACT*

*During regular monitoring of the marine protected area of Miramare (Gulf of Trieste, northern Adriatic Sea) in August and September 2010, a specimen of the dusky spinefoot* Siganus luridus *(Rüppell, 1828) was sighted, photographed and filmed. This is the first record of this Lessepsian migrant in the Adriatic Sea. Although only a single specimen was observed in the studied area, this record represents a further spreading of an alien species which has already established its populations in different countries of the eastern and southern Mediterranean Sea.*

**Key words:** *Siganus luridus*, dusky spinefoot, alien species, Lessepsian migration, Adriatic Sea

# PRIMA SEGNALAZIONE DEL PESCE CONIGLIO *SIGANUS LURIDUS* (RÜPPELL, 1828) IN MARE ADRIATICO

*SINTESI*

*Durante il regolare monitoraggio dell'Area Marina Protetta di Miramare (Golfo di Trieste, Adriatico settentrionale) nel periodo agosto-settembre 2010, un esemplare di pesce coniglio* Siganus luridus *(Rüppell, 1828) è stato avvistato, fotografato e filmato. Si tratta della prima segnalazione di questo migrante lessepsiano nel mare Adriatico. Benché un solo esemplare sia stato avvistato nell'area di studio, tale ritrovamento rappresenta un'ulteriore espansione dell'areale di distribuzione di una specie aliena, le cui popolazioni si sono già stabilite in diverse nazioni del Mediterraneo orientale e meridionale.*

**Parole chiave:** *Siganus luridus*, pesce coniglio, specie aliene, migranti lessepsiani, mare Adriatico

## INTRODUCTION

During the last decade, the number of records of alien macroalgae and animal species in the Mediterranean Sea has been increasing very rapidly. According to Zenetos *et al.* (2008), at least 903 alien species have been introduced into the Mediterranean Sea. Since the opening of the Suez Canal in 1869, there has been an influx of Red Sea and Indo-Pacific organisms into the Mediterranean Sea, a phenomenon known as lessepsian migration (Por, 1978). During the past decades, 74 lessepsian fish species have been recorded from the Mediterranean Sea (Golani, 2010), while 11 were reported from the Adriatic Sea (Dragičević & Dulčić, 2010). Biodiversity changes in the Mediterranean Sea occur at an exceptional rate, bringing the rate of introductions to 1 species every 1.5 weeks (Zenetos, 2010).

In this paper, the first record of the lessepsian migrant the dusky spinefoot *Siganus luridus* (Rüppell, 1828) in the Adriatic Sea is presented. On the basis of observations, photographs and movies taken of a single specimen of the dusky spinefoot *S. luridus,* this species could be added to the Adriatic checklist of fishes presented by Lipej & Dulčić (2010).

## MATERIAL AND METHODS

From 1992, regular monitoring of coastal fish fauna by means of visual census techniques has been conducted in the marine protected area (MPA) of Miramare (Gulf of Trieste). Since 2000, fish fauna monitoring has been performed at least once per week in the period from May to September and at least twice per month in the period from October to April. Visual censuses are performed by skilled divers of the WWF Miramare.

During regular monitoring of costal fish assemblage in August and September 2010, a specimen of the dusky spinefoot *S. luridus* was sighted, photographed (Fig. 1) and filmed at the locality of Bagno Ducale in the MPA of Miramare (Fig. 2). It was firstly sighted on 17 and 19 August, afterwards it was photographed on 28 August, while the movie of this specimen was taken on 13 September. At that time, the weather changed severely and the specimen has not been sighted anymore. The specimen was swimming together with other native fish, mostly wrasses (family Labridae), in the rocky habitat type at the depth of 1 to 2 m. The area where the specimen was detected is a typical habitat of the photophilous algae biocoenosis (degraded stage of the association of *Cystoseiretum crinitae*).

The specimen was photographed with a digital camera Nikon D2x with 60 mm Micro Nikkor lens, Seacam housing and Sea&Sea YS-120 flash. The photographs were sent to Daniel Golani from the Hebrew University in Jerusalem (Israel), who confirmed the identification.

## RESULTS AND DISCUSSION

On the basis of the set of digital photos, the specimen was identified as a member of the family Siganidae, according to its typical body shape and colour pattern. The species was determined due to the typical truncated caudal fin, which is forked in similar Lessepsian species

***Fig. 1: Specimen of** Siganus luridus**, photographed at the locality of Bagno Ducale in the WWF Miramare Marine Protected Area, Trieste. (Photo: D. Poloniato)***
***Sl. 1: Primerek vrste** Siganus luridus**, fotografiran na lokaliteti Bagno Ducale znotraj zavarovanega območja WWF Miramare pri Trstu. (Foto: D. Poloniato)***

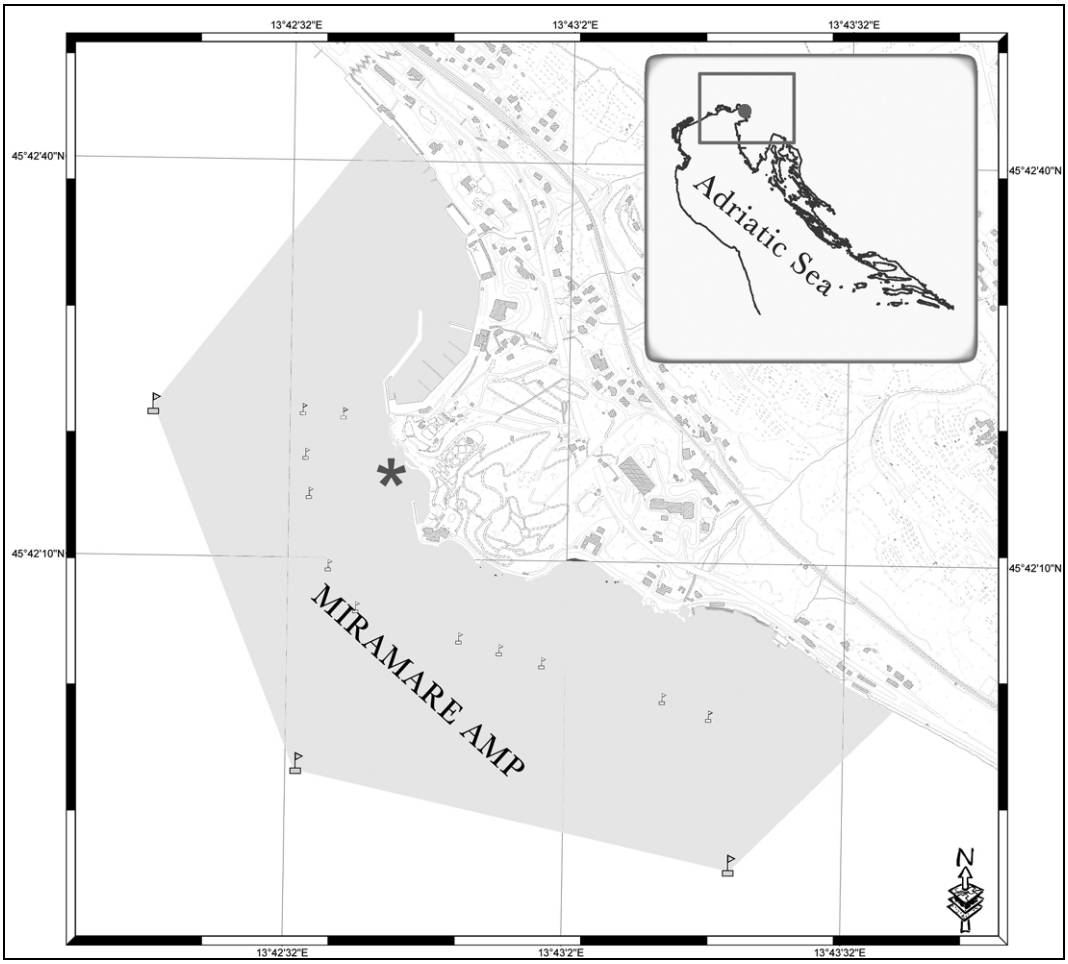


***Fig. 2: Map of the studied area with the locality, where the specimen of** S. luridus **was sighted.***
***Sl. 2: Zemljevid obravnavanega območja z lokaliteto, kjer je bil opazovan primerek vrste** S. luridus**.***

*Siganus rivulatus.* The most important diagnostic features are: body deep, ellipsoid, compressed; dorsal fin origin above pectoral fin base; dorsal ray portion margin round; caudal fin truncated; head slightly concave with blunt snout; mouth small with distinct lips; body dark brown to olive green with a touch of yellow on the fins.

In the past, photographs already served as reliable evidence for assessing the presence of certain rare or less known species (Dulčić *et al.,* 2006). Nowadays SCUBA diving equipment proved to be an optimal tool for assessing the ichthyofauna, especially in protected areas. This is especially true for certain cryptobenthic species, which are hard to be sampled with the classical destructive methods. Many rare or less known species such as *Millerigobius macrocephalus, Apletodon incognitus, Thorogobius ephippiatus* among others, were detected with SCUBA diving equipment for the very first time in the Gulf of Trieste (see Lipej *et al.,* 2005, 2007).

The first record of *S. luridus* in the Adriatic Sea represents a new species reported for the Adriatic ichthyofauna, which means that the total number of up to date recorded marine fish species is 442 (see Lipej & Dulčić, 2010). With the inclusion of *S. luridus,* the number of confirmed Lessepsian migrants in the Adriatic Sea rises to 12. However, the great majority of them were recorded only at single occasions (Dulčić *et al.*, 2003). In the Gulf of Trieste, the dusky spinefoot is the third alien fish species recorded up to date. On 16 May 1998, a 12 cm long orange-spotted grouper *Epinephelus coioides* was caught near Trieste and delivered to the Aquarium in Trieste alive (Parenti & Bressi, 2001). Five years later the specimen measured 52 cm in total length. The second alien fish recorded in the studied area was *Terapon theraps*, which was caught in nets in waters off Piran on 10 August 2007 (Lipej *et al.*, 2008).

The dusky spinefoot is one of the first lessepsian migrants in the Mediterranean Sea, since it was first discovered in Israeli waters in 1955 (Ben-Tuvia, 1964). One siganid, the marbled spinefoot *S. rivulatus* has already been reported in the Adriatic Sea by Dulčić & Pallaoro (2004), while *S. luridus* has up to date been recorded along the Levantine coast (see for example Go-

lani, 2010), Libya (Štirn, 1970), Tunisia (Ktari Chakroun & Bouhlal, 1971), waters off Turkey and Greece (see for example Bilecenoglu, 2010 and Corsini-Foka, 2010), and Italian waters (Azzurro & Andaloro, 2004; Castriota & Andaloro, 2005; Orsi-Relini, 2010). It was recently confirmed also for the French Mediterranean coast (Daniel *et al.*, 2009). Nowadays, *S. luridus* together with its congeneric species *S. rivulatus* has a commercial importance in the eastern and central south Mediterranean Sea (Shakman *et al.*, 2008).

The dusky spinefoot is a herbivorous fish that feeds mainly on coarse brown algae, and thrives in rocky shallow habitats covered with vegetation (Golani *et al.,* 2002). It has become dominant in many eastern Mediterranean coastal areas, where it competes with the main native herbivores, *Sparisoma cretense* and *Sarpa salpa* (Bariche *et al.,* 2004) and has altered the community structure and the native food web along the Levantine rocky infralittoral zone (Galil, 2007). Together with *S. rivulatus*, it is considered to be a common commercial fish in the Levantine Sea (Streftaris & Zenetos, 2006), and invasive in other parts of the eastern Mediterranean Sea.

Up to date about a third of all Lessepsian species have succeeded in dispersing over the Mediterranean Sea (Ben Rais Lasram *et al.*, 2008). The success of Lessepsian migrant fish species in colonization of the eastern Mediterranean was often explained as the exploitation of unsaturated niches (Golani, 2010). *S. luridus* and its Lessepsian congener *S. rivulatus* are typical herbivores, which succeed to colonize new areas due to the scarcity of native herbivorous fish (Lundberg & Golani, 1995). In a narrower aspect, *S. luridus* is considered to be a euryphagous herbivore, grazing on different algal species without preference. Lundberg *et al.* (1999) reported that the two *Siganus* species are rather selective when macrophyte assemblages are diverse and abundant, and will consume whatever is available during the unfavourable season. Galil (2007) discussed the impact the siganids were having on the Mediterranean biota, pointing out the results of some studies, which demonstrated that siganids had significant impact on the local algal community, causing even eradication of certain algal species. Recently it was assessed that both siganids species represented more than a third of total fish biomass in the rocky habitats in Israeli Mediterranean waters (Goren & Galil, 2005).

Sightings of a single specimen of *S. luridus* in a single locality should at the moment be taken only as a sign of an ordinary arrival of an alien species in the new environment of the Gulf of Trieste. At the very same time Por (1978) predicted that the expansion of Lessepsian immigrants in the Mediterranean Sea would be limited by minimum winter surface temperature lower than 16 °C. However, since the dusky spinefoot is known to be one of the so-called Lessepsian species with strong dispersal (*sensu* Ben Rais Lasram *et al.*, 2008), the success of the dusky spinefoot in the Mediterranean Sea was attributed to its large eco-physiological plasticity. This species has adapted its feeding regime to the new environmental conditions (Lundberg & Golani, 1995), showing high competitive potential to the detriment of indigenous species (Stergiou, 1988). Its spawning season has shortened, probably in relation to the varied seawater temperatures that are found in the Mediterranean Sea (Bariche *et al.,* 2003). Hassan *et al.* (2003) reported the absence of genetic differentiation between the Mediterranean Sea and the Red Sea populations, with exclusion of bottleneck events. These characteristics, together with the recent Adriatic and Mediterranean Sea warming, give us reason to suppose that *S. luridus* is a potential invader of the Adriatic Sea. The present record does not allow any confident comment to be made regarding whether or not the species has established a breeding population in the area. However, although only a single specimen was observed in the studied area, this record represents a further spreading of an alien species which has already established its populations in different countries of the eastern and southern Mediterranean Sea. A speculative reason for the spreading success of this species in the new environment is that it presumably occupied an unsaturated ecological niche with only scarce herbivorous indigenous fish species (Golani *et al.,* 2002). In any event, the impact of possible successful colonization by this and other exotic fish species would at least represent a change in the composition of the native ichthyofauna.

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# PRVI ZAPIS O POJAVLJANJU TEMNEGA MORSKEGA KUNCA *SIGANUS LURIDUS* (RÜPPELL, 1828) V JADRANSKEM MORJU

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*Tekom rednega monitoringa ribjih združb v zavarovanem območju Miramare pri Trstu (Tržaški zaliv) v avgustu in septembru 2010 je bil opažen, fotografiran in s podvodno videokamero posnet primerek temnega morskega kunca* Siganus luridus *(Rüppell, 1828). Gre za prvo opazovanje te lesepske selivke v Jadranskem morju. Navzlic enemu samemu opaženemu primerku na obravnavanem območju ta zapis predstavlja nov dokaz o širjenju areala te vrste v Sredozemskem morju. V mnogih obmorskih državah vzhodnega in južnega dela Sredozemlja se je ta tujerodna vrsta že ustalila in ustvarila stabilne populacije.*

**Ključne besede:** *Siganus luridus*, temni morski kunec, tujerodna vrsta, lesepska selitev, Jadransko morje

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# ADDITIONAL RECORDS OF THE BULL RAY *PTEROMYLAEUS BOVINUS* (CHONDRICHTHYES: MYLIOBATIDAE), IN THE LAGOON OF BIZERTE (NORTHERN TUNISIA, CENTRAL MEDITERRANEAN)

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## *ABSTRACT*

*The authors report on the capture of two large bull rays* Pteromylaeus bovinus *(Geoffroy Saint-Hilaire, 1817) in the Lagoon of Bizerte, a brackish area located in northeastern Tunisia. The specimens were 1110 mm and 1050 mm in disk width (DW), respectively, and weighed 16,200 g and 14,800 g, respectively. They are the largest bull rays recorded in Tunisian waters, a perimediterranean lagoon, and probably in central and southern Mediterranean. Theses captures are commented and discussed.*

**Key words:** Chondrichthyes, Myliobatidae, *Pteromylaeus bovinus*, Lagoon of Bizerte, northern Tunisia, maximum size

# SEGNALAZIONI AGGIUNTIVE DI VACCARELLA, *PTEROMYLAEUS BOVINUS* (CHONDRICHTHYES: MYLIOBATIDAE), NELLA LAGUNA DI BIZERTE (TUNISIA SETTENTRIONALE, MEDITERRANEO CENTRALE)

*SINTESI*

*Gli autori segnalano la cattura di due individui di grossa taglia di vaccarella,* Pteromylaeus bovinus *(Geoffroy Saint-Hilaire, 1817), nella Laguna di Bizerte, area salmastra della Tunisia settentrionale. Gli individui presentavano una larghezza del disco (DW) pari a 1110 mm e 1050 mm, e pesavano 16.200 g e 14.800 g, rispettivamente. Si tratta dei due esemplari di vaccarella più grandi mai catturati in acque della Tunisia, in una laguna perimediterranea, e probabilmente nel Mediterraneo centrale e meridionale. Nell'articolo tali catture vengono commentate e discusse.*

**Parole chiave:** Chondrichthyes, Myliobatidae, *Pteromylaeus bovinus*, Laguna di Bizerte, Tunisia settentrionale, taglia massima

## INTRODUCTION

The bull ray, *Pteromylaeus bovinus* (Geoffroy Saint-Hilaire, 1817), is a typical atlanto-mediterranean species, known in the eastern Atlantic from Portugal to South Africa (McEachran & Capapé, 1984) and also off southern Mozambique (Compagno *et al.*, 1989), while in the Mediterranean, *P. bovinus* is more frequently captured in the eastern than in the western basin, more often in southern areas (Capapé, 1989; Zogaris & Dussling, 2010). However, the bull ray was previously reported as a rare elasmobranch species in the Adriatic Sea (Šoljan, 1975; Jardas, 1985), but recent investigations allow the capture of several specimens and provide thorough data on the life history of *P. bovinus* from the area (Dulčić *et al.*, 2008).

Southward, *P. bovinus* was reported throughout the Maghreb shore and especially in Tunisian marine waters (Capapé & Quignard, 1975; Bradaï *et al.* 2004). Investigations conducted in Tunisian waters showed that *P. bovinus* migrated toward northern areas and entered brackish water areas such as the Lagoon of Bizerte (Neifar *et al.*, 1999; El Kamel *et al.*, 2009) and Tunis Southern Lagoon (Mejri *et al.*, 2004). The recent captures of two specimens in the Lagoon of Bizerte are herein reported and commented.

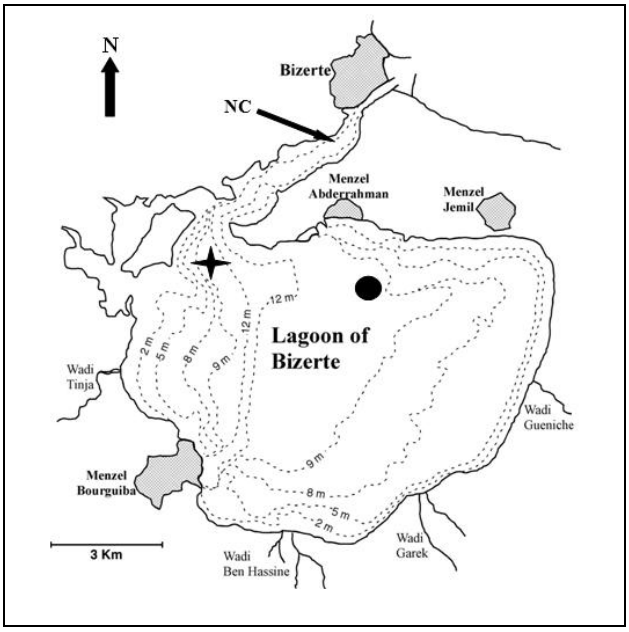


***Fig. 1: Map of the Lagoon of Bizerte showing the navigation channel (NC), the capture sites of both adult male*** *Pteromylaeus bovinus* ***(black star) and both neonate specimens (black circle; see El Kamel*** *et al.****, 2009).***
***Sl. 1: Zamljevid Lagune Bizerte z označenim navigacijskim kanalom (NC) ter točkama ulova obeh odraslih samcev*** *Pteromylaeus bovinus* ***(črna zvezda) in obeh novorojenih primerkov (črna pika; glej El Kamel*** *et al.****, 2009).***

## MATERIAL AND METHODS

Two bull rays were captured by longline on 08 October 2010 at depths between 8 and 12 m, in the northeastern area of the Lagoon of Bizerte, close to the navigation canal (Fig. 1). The Lagoon of Bizerte is a brackish area located in northeastern Tunisia, between 37°8′ N and 37°14′ N, and between 9°46′ E and 9°56′ E. Both specimens were landed at the fishing site of Menzel-Abderrahaman by fishermen. Species identification follows Capapé & Quignard (1975) and McEachran & Capapé (1984), while morphometric measurements to the nearest mm and mass to the nearest gram follows Mejri *et al.* (2004). Photographs of both specimens were available.

## RESULTS AND DISCUSSION

The two *P. bovinus* captured in the Lagoon of Bizerte were 1110 mm and 1050 mm in disk width (DW), respectively, and weighed 16,200 g and 14,800 g, respectively (Fig. 2). They were adult males having rigid, calcified and large claspers longer than pelvic fins. Morphometric measurements of both specimens are presented in Table 1. The following description is based on both specimens: head large, snout prominent, narrower than the skull, blunted at the tip. Rostral fins at lower level and separate from pectoral fins along the side of the head. Pectoral fins with outer angle acute strongly falciform. Spiracles large, 3 times as long as wide. Tail slender and elongated with dorsal fin beginning in front of tips of pelvic fins. Pre-orbital horns well-developed.

***Fig. 2: Both specimens of*** *P. bovinus* ***captured in the Lagoon of Bizerte, scale bar = 500 mm.***
***Sl. 2: Primerka*** *P. bovinus****, ujeta v Laguni Bizerte, merilo = 500 mm.***

Dorsal surface naked with small tubercles down midline of disc. Dorsal plain brown in adults, slightly darker between the eyes, along the center of the body and the length of the tail. Caudal sting beige. Belly off-white to beige.

Morphology, measurements and colour of both specimens are in agreement with Capapé & Quignard (1975), McEachran & Capapé (1984), Seck *et al.* (2002), Dulčić *et al.* (2008) and Lipej *et al.* (2009). Such captures once again confirm the migration towards northern Tunisian areas of a species previously considered to have sub-tropical affinities (Postel, 1956; Bradaï *et al.*, 2004). Similar instances have been reported in Tunisian waters, and concern elasmobranch species such as the spiny butterfly ray, *Gymnura altavela* (Linnaeus, 1758) and other teleost species such as the filefish *Stephanolepis diaspros* (Fraser-Brünner, 1940) found in the Lagoon of Bizerte (Bdioui et *al.*, 2004) and off Tabarka, a city located close to the Algerian border (Ben Amor & Capapé, 2008), the blunthead puffer *Sphoeroides pachygaster* (Müller & Troschel, 1848), recorded in northern areas by Chérif *et al.* (2010), and a Lessepsian migrant, the Por's goatfish *Upeneus pori* Ben-Tuvia & Golani, 1989, also recently recorded in the Lagoon of Bizerte (Azzouz *et al.*, 2010). Such records could be due to the fact that Tunisian marine waters become warmer than waters in other Mediterranean areas (Quignard & Tomasini, 2000). These records agree with Golani's opinion (Golani, 1998), stating that once a lessepsian migrant species or other alien species arrive to the Mediterranean and establish a self-sustaining population, there are no physical barriers preventing its dispersion everywhere.

The capture of two large bull rays inside the Lagoon of Bizerte shows that the navigation channel does not really constitute the main obstacle for the entrance of large species in the area, as it was previously reported by El Kamel *et al.* (2009) who noted that only small-sized elasmobranch species were recorded in this brackish area. The bull rays previously found in the Lagoon of Bizerte were two small specimens, probably neonates according to El Kamel *et al.* (2009). All findings suggest that a sustainable *P. bovinus* population is at present established in the area, probably due to the fact that in the Lagoon of Bizerte the species has found abundance of mussels, oysters and several gastropod

***Tab. 1: Morphometric measurements and percents of disk width (% DW) of both specimens captured in the Lagoon of Bizerte.***
***Tab. 1: Morfometrični podatki in odstotki širine telesne plošče (% DW) obeh primerkov, ujetih v Laguni Bizerte.***

| **Sex** | **male** | | **male** | |
|---|---|---|---|---|
| **Total mass (g)** | 16200 | | 14800 | |
| **Morphometric measurements** | mm | % DW | mm | % DW |
| Total length | 1600.0 | 144.1 | - | - |
| Disk length | 740.0 | 66.7 | 710.0 | 67.6 |
| Disk width (DW) | 1110.0 | 100.0 | 1050.0 | 100.0 |
| Disk depth | 90.0 | 8.1 | 90.0 | 8.6 |
| Snout length | 110.0 | 9.9 | 80.0 | 7.6 |
| Snout tip to pectoral | 115.0 | 10.4 | 115.0 | 11.0 |
| Anterior interspiracular width | 120.0 | 10.8 | 120.0 | 11.4 |
| Inter-nasal width | 60.0 | 5.4 | 60.0 | 5.7 |
| Mouth width | 80.0 | 7.2 | 70.0 | 6.7 |
| Width between first gill slit | 140.0 | 12.6 | 140.0 | 13.3 |
| Width between fifth gill slit | 96.0 | 8.6 | 90.0 | 8.6 |
| Snout tip to vent | 620.0 | 55.9 | 590.0 | 56.2 |
| Pectoral fin anterior margin | 540.0 | 48.6 | 510.0 | 48.6 |
| Pectoral fin posterior margin | 470.0 | 42.3 | 500.0 | 47.6 |
| Pectoral fin inner margin | 111.0 | 10.0 | 90.0 | 8.6 |
| Pelvic fin anterior margin | 130.0 | 11.7 | 140.0 | 13.3 |
| Pelvic fin posterior margin | 70.0 | 6.3 | 90.0 | 8.6 |
| Pelvic fin inner margin | 60.0 | 5.4 | 40.0 | 3.8 |
| Clasper length | 110.0 | 9.9 | 110.0 | 10.5 |
| Dorsal anterior edge | 75.0 | 6.8 | 75.0 | 7.1 |
| Dorsal posterior edge | 65.0 | 5.9 | 50.0 | 4.8 |
| Dorsal base | 85.0 | 7.7 | 85.0 | 8.1 |

***Tab. 2: Size at birth and maximum size (DW, mm) in male** P. bovinus **captured in the Lagoon of Bizerte and records given by authors from different marine areas.***
***Tab. 2: Velikost ob rojstvu in maksimalna velikost (DW, mm) samcev** P. bovinus**, ujetih v Laguni Bizerte, in podatki avtorjev iz drugih morskih območij.***

| Area | Size at birth (DW, mm) | Maximal size (DW, mm) | Authors |
|---|---|---|---|
| Coast of Tunisia | 250-290 | 1040 | Capapé & Quignard, 1975 |
| Mediterranean | 450 | - | McEachran & Capapé, 1986 |
| Coast of Senegal | 250-270 | 1150 | Seck *et al.*, 2002 |
| Tunis Southern Lagoon | 310 | - | Mejri *et al.*, 2004 |
| Northern Adriatic | 370-450 | 1135 | Dulčić *et al.*, 2008 |
| Lagoon of Bizerte | 426-450 | 1100 | This study |

species which constitute the main food of *P. bovinus* (see Capapé, 1976). To date, *P. bovinus* should be considered a marginal species rather than a sedentary one in this restricted area following the definition of Aidan Martin (2005). Additionally, the fishing pressure is rather important in the Lagoon of Bizerte; elasmobranch species such as *P. bovinus* are consumed by local population with low income and are not discarded at sea after capture (El Kamel *et al.*, 2009). *P. bovinus* is vulnerable to fishing pressure because it adheres to K-selected life-histories (*sensu* McAuley *et al.*, 2007) as other elasmobranch species, and their recruitment remains difficult. Additionally, recent investigations showed that *P. bovinus* is not very abundant in the neighbouring shallow coastal waters (Mnasri, 2008).

On the other hand, despite these unfavourable environmental and biological parameters, the observed male specimens were larger than males previously recorded by Capapé & Quignard (1975). As data in Table 2 show, their maximum size was similar to that of bull rays from Senegal (Seck *et al.*, 2002) and northern Adriatic (Dulčić *et al.*, 2008). Additionally, they were the largest male *P. bovinus* and concomitantly the largest elasmobranch ever recorded in a restricted area, a perimediterranean lagoon (*sensu* Quignard & Zaouali, 1980). Such sizes may be occasional, and could also be the result of the ecological environment of the Lagoon of Bizerte in relation to the food and feeding habits of the species.

**ACKNOWLEDGEMENTS**

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# NOVI PODATKI O KLJUNATEM MORSKEM GOLOBU *PTEROMYLAEUS BOVINUS* (CHONDRICHTHYES: MYLIOBATIDAE) IZ LAGUNE BIZERTE (SEVERNA TUNIZIJA, OSREDNJE SREDOZEMLJE)

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*POVZETEK*

*Avtorji prispevka poročajo o ulovu dveh velikih primerkov kljunatih morskih golobov* Pteromylaeus bovinus (*Geoffroy Saint-Hilaire, 1817*) *v Laguni Bizerte, brakičnem območju v severnovzhodni Tuniziji. Širina telesne plošče*

*(DW) primerkov je bila 1110 mm in 1050 mm, tehtala pa sta 16.200 g in 14.800 g. Gre za največja primerka kljunatih morskih golobov zabeležena v tunizijskih vodah, perimediteranski laguni in po vsej verjetnosti južnem Sredozemlju.*

**Ključne besede:** Chondrichthyes, Myliobatidae, *Pteromylaeus bovinus*, Laguna Bizerte, severna Tunizija, maksimalna velikost

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# A REVIEW OF NEWSPAPER AND INTERNET PORTRAYALS OF THE SIXGILL SHARK, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE), CAUGHT IN TURKISH WATERS BETWEEN 1974–2009

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## *ABSTRACT*

*Analysis of 81* Hexanchus griseus *related articles published in major Turkish newspapers and internet media between 1974 and 2009 revealed that the tenor of the coverage was neutral in 40 (49.3%) articles, 37 (45.6%) were negative and only 4 (4.9%) were positive. A utilitarian perspective prevailed, appearing in 51 (62.9%) of the articles examined. Since 2004, the diversification of media opportunities has caused an increase in the number of published articles on* H. griseus. *In Turkey, people share the preconceived notion of sharks that has been deeply embedded into their psychology by years of irresponsible media reporting. Articles depicting the sixgill shark as a possible source of profit can motivate the fishermen to catch this vulnerable species and cause an artificial fishing pressure on* H. griseus.

**Key words:** Sixgill shark, *Hexanchus griseus*, Turkey, portrayals, media, conservation

# REVISIONE DI RITRATTI PUBBLICATI SU GIORNALI ED INTERNET DI SQUALO CAPOPIATTO, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE), CATTURATO IN ACQUE TURCHE NEL PERIODO 1974–2009

## *SINTESI*

*L'autore presenta l'analisi di 81 articoli correlati a* Hexanchus griseus, *pubblicati dai più importanti giornali della Turchia e sul Web nel periodo 1974–2009. I risultati dell'analisi evidenziano che il tono di copertura era neutrale in 40 articoli (ossia nel 49,3% dei casi), negativo in 37 articoli (45,6% dei casi) e positivo in soli 4 articoli (4,9% dei casi). In 51 articoli esaminati (62,9% dei casi) prevaleva una prospettiva utilitaria. La diversificazione delle oppurtunità offerte dai mass media ha causato un aumento del numero di articoli pubblicati su* H. griseus *a partire dal 2004. In Turchia la popolazione condivide i pregiudizi sugli squali, che sono stati profondamente radicati nella loro psicologia da anni di servizi giornalistici irresponsabili. Gli articoli che descrivono lo squalo capopiatto quale possibile fonte di guadagno possono motivare i pescatori a catturare questa specie vulnerabile e causare una pressione artificiale di pesca su* H. griseus.

**Parole chiave:** squalo capopiatto, *Hexanchus griseus*, Turchia, ritratti, mass media, conservazione

## INTRODUCTION

In a 2005 study dealing with the grey nurse shark (*Carcharias taurus*) and human interactions, Boissonneault *et al*. (2005) analyzed the impact of the newspaper media on attitudes and understandings that the public had developed towards the grey nurse shark. The study consisted of a content analysis of the articles published in major Australian newspapers over a prescribed period of time, and concentrated on the way the species was portrayed in these articles. Boissonneault *et al*. (2005) concluded that the amount of interest that was generated on the topic could have a direct impact on the conservation of the grey nurse shark itself.

The sixgill shark *Hexanchus griseus* (Bonnaterre, 1788) is a wide-ranging hexanchid shark in both the northern and southern hemisphere (Compagno, 1984). Although many shark species occurring in the seas of Turkey are in danger of extinction, this study will concentrate on the portrayal of the sixgill shark *H. griseus* in various Turkish newspapers and internet media. *H. griseus* is not consumed by humans in Turkey. It is a rare by-catch by Turkish fishermen and incidentally captured specimens are generally landed for display. Public and media interest in large sharks as well as fishermen's anticipation of extra benefits from incidentally captured sixgill sharks are the main reasons for such landings. Recently, Kabasakal (2006) reported on 60 sixgill sharks incidentally caught and landed by the commercial fishermen in Turkish waters. According to most recent surveys of newspaper and internet articles, as well as field observations of specimens displayed at fishmongers', the total number of the by-caught sixgill sharks in Turkish waters between 1974–2009 increased to 128 (H. Kabasakal, *unpubl. data*). *H. griseus* is considered as 'vulnerable' on the Red List of IUCN/SSG (Soldo, 2003). Therefore, implementation of an effective conservation strategy for sixgill shark is urgently needed (Kabasakal, 2006).

Since the formation of Ichthyological Research Society (I.R.S.) in 2000, the author has been collecting newspaper and internet articles, dealing with the sixgill sharks caught by Turkish fishermen, as part of an extensive research in order to determine the current status of sharks in Turkish waters. The primary aim of the present article is to draw a general portrayal of the sixgill shark based on the mentioned newspaper and internet articles. Furthermore, defining public attitudes about the sixgill sharks and the impact of media news on the conservation of the species are discussed.

## METHODS

Following the research design of Boissonneault *et al*. (2005), which was adapted from Wolch *et al*. (1997), a content analysis was conducted on 81 *H. griseus* related articles appearing in newspapers such as *Akşam*, *Hürriyet*, *Milliyet*, *Posta*, *Sabah*, *Stargazete*, *Takvim*, *Tercüman*, *Vatan* and *Yeni Asya*, and on several websites, between 1974 and 2009. The selection of specific newspapers and websites for this study depended on availability. The articles were gathered through the use of library archives for the years prior to their inclusion in online newspaper databases, screening the daily issues of newspapers and through an internet search. They were chosen on the basis of content referring specifically to the sixgill shark. Articles appearing in different newspapers were only considered as one when the content of the articles was identical.

The attitudes expressed within the article, as classified through the use of Kellert's (1985) typology of attitudes towards animals (in Boissonneault *et al*., 2005), were used to determine the overall tone of an article *i.e.*, positive/supportive, negative/oppositional, or neutral. The overall tone of the articles, as distinguished by the attitudes expressed in each of the articles, was analyzed from a qualitative perspective. This tone was determined from an examination of: (a) specific attitudes that illustrate either a humanistic, moralistic, utilitarian, negativistic, dominionistic, naturalistic or ecologistic perspective; (b) the terminology used (e.g. an article using such terms as 'monster' or 'intruder', and phrases such as 'the worst nightmare' or 'the best shark is the dead shark', would be deemed negative) and (c) any informational bias, which refers to the way in which the available information source, i.e. scientists or lack thereof, can sway the decision-maker or reader (Boissonneault *et al.,* 2005).

Kellert's (1985) typology of attitudes towards animals (in Boissonneault *et al*. 2005) is used to assess individual statements within these articles (Tab. 1). Within Kellert's model, the range in attitudes varies from a belief that the purpose of animals is to serve as resources for humans (*i.e.* utilitarianism and dominionism) to attitudes that accentuate kindness towards animals whereby the ethical treatment of animals is defended (*i.e.* humanism and moralism), as well as the absence of concern or even negative attitudes towards animals *(i.e.* negativistic attitudes). This analysis was conducted following the standard tenets of qualitative methodology.

## RESULTS AND DISCUSSION

Distribution of 81 *H. griseus* related articles by years is presented in Fig. 1. Only one article on sixgill shark was published in 1974, and the lack of articles on *H. griseus* is obvious throughout the subsequent twenty years (Fig. 1). The missing years within the graph shown in figure 1 are representative of years in which articles pertaining specifically to *H. griseus* were either not found or not published. With regard to 59 articles (72.8%; 9.8 articles per year) published between 2004–2009 only 22 articles (27.1%; 2.2 articles per year) published between 1974–2003 were obtained (Fig. 1). The

***Tab. 1: Attitudes towards animals (Kellert, 1985; in Boissonneault** et al.**, 2005).***
***Tab. 1: Odnos do živali (Kellert, 1985; v Boissonneault** et al.**, 2005).***

| | |
|---|---|
| Humanistic | Interest and strong affection for individual animals, principally pets. |
| Moralistic | Concern for the right and wrong treatment of animals, with strong opposition to the exploitation and cruelty toward animals. |
| Utilitarian | Concern for the practical and material value of animals or their habitats. |
| Negativistic | Avoidance of animals due to indifference, dislike or fear. |
| Dominionistic | Interest in the mastery and control of animals, typically in sporting situations. |
| Naturalistic | Interest and affection for wildlife and the outdoors. |
| Ecologistic | Concern for the environment as a system, for interrelationships between wildlife and natural habitats. |

numerical scarcity of *H. griseus* specific articles during 1974–2003 period suggests that sixgill shark might not be newsworthy in those years. Furthermore, with regard to locality of capture of the sixgill sharks appearing in the articles between 1974–2000 in particular, it was found that most of the specimens were caught in the adjacent waters of İstanbul city where headquarters of the significant newspapers with high circulation rates are located. Therefore, it is possible to suggest that sixgill sharks caught in remote localities far from İstanbul, were not accessed by the reporters, and therefore, not included in the contents of the analysed newspapers published between 1974–2000. It is important to note that a marked increase in the number of sixgill shark articles has been observed since 2004, which coincides with the increase of online newspaper articles on the topic in Turkish internet media. Thus, sixgill shark captures which were previously not included in the content of daily newspapers, could find room for publication and become accessible.

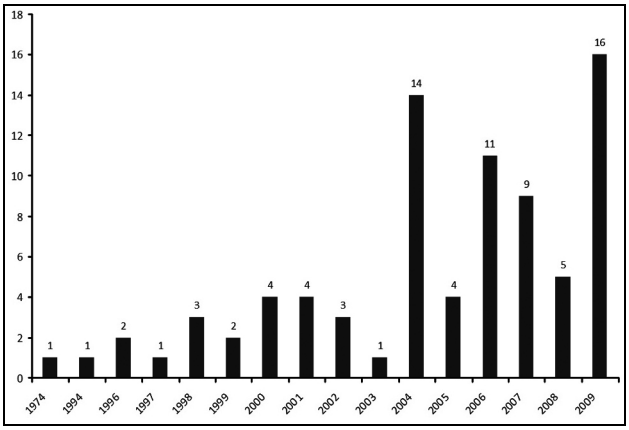


***Fig. 1: Number of articles on the capture of sixgill sharks, published in the period between 1974 and 2009.***
***Sl. 1: Število člankov o ulovu morskega psa šesteroškrgarja, objavljenih v obdobju med letoma 1974 in 2009.***

Figure 2 is an example of how the articles have been assessed with reference to their tone over the years covered in this study. Of the 81 articles about the sixgill shark that this study has identified, the tenor of the coverage was neutral in 40 (49.3%) articles, 37 (45.6%) were negative and only 4 (4.9%) were positive (Fig. 2). In neutral and negative articles pertaining to *H. griseus*, sixgill shark was frequently labelled as 'jaws' in 27 (33.3%) of them. The first appearance of the term 'jaws' in an article was on 10 July 1994. It has been the most frequent term used for defining the sixgill shark; the most recent appearance of this term in an article was on 15 December 2009. Another term frequently appearing in the articles was 'the giant shark'. This term appeared in 17 (20.9%) articles, the first time on 29 November 2004 and most recently on 8 December 2009, respectively. Another term used for negatively defining the sixgill shark was 'monster'; it appeared in 9 (11.1%) articles, the first time on 26 November 1974 and most recently on 18 December 2007, respectively.

The most common attitudes used to describe the sixgill shark within the 81 articles examined were struggle (18; 22.2%), aggressor (10; 12.3%), anxiety/terror (10; 12.3%), panic/fear (10; 12.3%), astonishment (9; 11.1%), intruder (4; 4.9%) or nightmare (3; 3.7%). With special reference to term 'intruder', exaggerated denotations claiming that 'the sixgill shark is a pestering monster occurring in the seas of Turkey' or 'the population of the sixgill shark is excessively increased in certain localities along the Turkish coast', were used in the articles published on 28 November 2006 and 30 March 2007. Similar exaggerated statements were observed in the articles where the term 'aggressor' appeared. In 18 (22.2%) of the examined articles, negative statements which can directly provoke shark fear were used deliberately. For example, in the article published on 18 July 2000, 'the best shark is a dead shark' statement was used to portray the sixgill shark. Terms such as 'nightmare' or 'baby killer', were also used to describe the sixgill shark in the articles published on 9 May 2005 and 16 April 2007, respectively. Continually juxtaposing *H.*

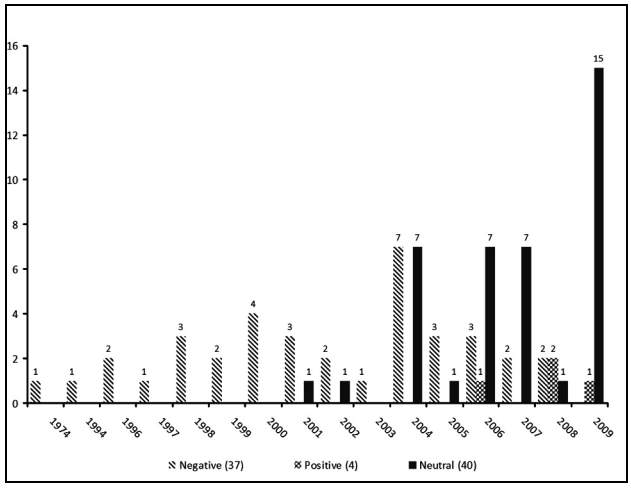


***Fig. 2: Tone of articles, depicting the sixgill shark in different perspectives, per year.***
***Sl. 2: Ton poročanja v člankih, ki prikazujejo morskega psa šesteroškrgarja v različnih perspektivah, na leto.***

*griseus* with such terms reinforces the perception that the species is dangerous even when the initial alarmist descriptor is undervalued within the later context of the article.

In 17 (20.9%) of the examined articles, the sixgill shark was misidentified or misnamed. In 15 (88.2%) out of 17 articles, the sixgill shark were named as 'pamuk balığı = cotton shark'. In the article published on 24 July 2006, the sixgill shark was named as 'blue shark,' a totally different species. The sixgill shark (*H. griseus*) was misidentified as *Carcharodon carcharias* (great white shark) or *Galeorhinus galeus* (tope shark) in the articles published on 3 December 2006 and 22 January 2009, respectively.

The tenor of the coverage of only 4 articles (4.9%) examined in this study was positive (Fig. 2), and found presenting reliable and scientifically proven information on the sixgill shark. Of the positive articles pertaining to the sixgill shark, scientific name of the species (*Hexanchus griseus*) was used in only 1 (1.2%) article. Turkish common name of *H. griseus*, 'bozcamgöz = grey shark', was used in 2 (2.4%) articles. Two of these four articles presented the expert opinion, and emphasised that the sixgill shark was a vulnerable species. Furthermore, three of these four articles highlighted that the sixgill shark was not a proven man-eater, and emphasised that as *H. griseus* was a deep-water inhabitant and rose to surface in dusk, the possibility of a man and sixgill shark encounter was remarkably low.

Based on the Kellert's (1985, in Boissonneault *et al.* 2005) typology of attitudes towards animals, a utilitarian perspective prevailed appearing in 51 (62.9%) articles observed. 38 (46.9%) out of these 51 articles suggest that the landed sixgill sharks are sold, but no information on the price of the sold sharks was given. Price information appeared in 13 (16.0%) articles, and ranged from 1.5 to 30 Turkish Lira (TL; 1 to 15 US$). According to the article published on 24 July 2006, a whole sixgill shark was sold for 2000 TL (750 US$).

With the expanding utilization of internet services in Turkish media since 2000s, articles pertaining to the sixgill sharks caught in remote localities along the coast of Turkey became accessible. The resultant diversification of media opportunities has caused an increase in the number of published articles on *H. griseus*, in particular since 2004 (Fig. 1). The highest number of the published articles pertaining to the sixgill shark was recorded in 2009.

The data generated by this study serve to exemplify the perceptions of *H. griseus* as represented by major Turkish newspapers and internet media between 1974 and 2009. The way in which an article describes its subject may generate an image within the reader that the author is trying to portray (Boissonneault *et al.*, 2005). This particular image that is constructed serves to accentuate the opinion that is being conveyed within the written piece and has the ability to shape public attitudes towards the issue at hand. Negative portrayals of the predatory animals, such as sharks, created by the mass media, can have tremendous effects on conservation efforts (Wolch *et al.*, 1997; Boissonneault *et al.*, 2005). Furthermore, it has been established that certain aspects of a species such as its usefulness, perceived intelligence, dangerous or loveable and attractive qualities can considerably impact public opinion (Driscoll, 1995). The power that the popular media holds when it comes to forming and influencing the public's perception of sharks is best illustrated by 1975 film Jaws (Peschak, 2006). Almost overnight the great white shark was subjected to a fatal metamorphosis from an obscure ocean dweller to a man-eating monster. In the wake of the film, a great white hunting frenzy followed, provoked and driven by an irrational and exaggerated fear of shark attack; it brought *C. carcharias* near the edge of extinction in several parts of the world oceans.

The fear of sharks is not something humans are born with but is a product of environment and culture. The power the media holds in influencing the public's perception of sharks is tremendous. Regarding agenda--setting, the media therefore has a responsibility to ensure that its content is factually correct since it is nearly impossible for non-specialists to separate scientific facts from science fiction. However, as Peschak (2006) has recently emphasized, especially in the daily news sectors the media often fails in its responsibilities by publishing incorrect information, elevating non-qualified people and their opinions to expert status and perpetuating unrealistic shark stories. Although the Turkish common name of *H. griseus*, 'bozcamgöz', has been known since the first writings on the marine fishes of

Turkey (Deveciyan 1926), it was used only in 2.4% of the articles examined. This example indicates how the authors of the articles neglect the facts and elevate irrelevant information about the sixgill shark.

In the remote corners of the western Pacific, sharks are worshipped and revered as gods (Taylor, 1985; Peschak, 2006). According to Pacific islanders, sharks are believed to harbour the souls of long departed and cherished ancestors. In Turkey, unlike in the western Pacific, people share the preconceived notion of sharks that has been deeply embedded into their psychology by years of irresponsible media reporting. Whether deliberately or not, the media perpetuate the fear of sharks and the negative image of a blood-thirsty and fearsome animal on a daily basis.

According to Peschak (2006), the reason for perpetuating the fear of shark by media is a well-known fact that shark stories, especially sensational shark bite stories sell. Corbett (1992) states that in higher-circulation newspapers the old axiom of 'bad news sells' will prevail concentrating the reportage of wildlife around problematic human-animal interactions *e.g.,* an attack. During the survey of newspaper and internet articles, it was observed that the similar sixgill shark can appear in several articles published in a few subsequent days, in which the coverage more or less garnished compared to previous article. Based on the case of *C. taurus*, Boissonneault *et al.* (2005) pointed out that the amount of manipulation generated on the topic, as well as conflict and adversarial presentation of issues within the media, could have a direct impact on the conservation of the species itself. Although the tone of the article published on 3 November 2008 was generally positive, the picture showing a dummy arm between the jaws of the sixgill shark (Fig. 3), depicted *H. griseus* as a man-eater. This is an obvious illustration of how accidental mistakes can unfairly juxtapose the sixgill shark with the man-eater reputation. Due to similar newspaper articles, which continually juxtaposed *C. taurus* with the term man--eater reinforces the perception that the species is dangerous even when the initial alarmist descriptor is undervalued within the later context of the article (Boissonneault *et al.*, 2005). Articles written without any concern of conservation or scientific facts serve to portray the predatory animals as criminals in the mind of the reader.


***Fig. 3: (a) Sixgill shark displayed at the fishmonger's. (Photo: H. Kabasakal); (b) The photograph of the same sixgill shark, published in a major Turkish newspaper on 3 November 2008, arrow denotes the dummy arm between the jaws of the specimen.***
***Sl. 3: (a) Morski pes šesteroškrgar, razstavljen v ribarnici. (Foto: H. Kabasakal); (b) fotografija istega morskega psa šesteroškrgarja, objavljena v večjem turškem časopisu 3. novembra 2008, puščica kaže na umetno roko v čeljustih primerka.***

## CONCLUSIONS

Due to its life-history characteristics (slow rate of growth, long living, low number of fecundity etc.) (Lipej *et al.*, 2004; COSEWIC, 2007), *H. griseus* is considered a 'K-selected' species. Therefore, like many other shark species, even the sustainable fishery strategies can cause dramatic declines in the stocks of the sixgill shark. *H. griseus* has been the focus of at least three known directed fisheries in Canadian waters during 20$^{th}$ century; however, all these attempts terminated due to conservation concerns (COSEWIC 2007). Not only the decline of the stocks of commercially important bony fishes, but the irresponsibly written articles, without scientific facts about the sixgill sharks, can have negative impacts on the survival of *H. griseus*. Similarly, articles depicting the sixgill shark as a possible source of profit can motivate the fishermen to catch this vulnerable shark and cause an artificial fishing pressure on *H. griseus*. In addition to subjecting *H. griseus* to 100% protection in the seas of Turkey, refining the articles about the sixgill shark from the triangle of blood, fear and irrelevant or erroneous information is an obvious necessity for the conservation of the species.

## ACKNOWLEDGMENTS

The author would like to thank Mr. Agop Savul, an Istanbul based book collector, for his valuable contributions during the archival search of old newspapers, and two anonymous referees for their valuable comments, which were very useful for the improvement of the manuscript. A special thank goes to Mrs. Özgür Kabasakal, for her patience and endless support.

# PREGLED ČASOPISNIH IN MEDMREŽNIH PRIKAZOV MORSKEGA PSA ŠESTEROŠKRGARJA *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE), UJETEGA V TURŠKIH VODAH V LETIH 1974–2009

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*POVZETEK*

*Analiza 81 člankov o vrsti* Hexanchus griseus*, objavljenih v večjih turških časopisnih in internetnih medijih v letih 1974–2009, pri 40 člankih (49,3%) ugotavlja nevtralno poročanje, pri 37 (45,6%) negativno in samo pri 4 (4,9%) pozitivno. Prevladuje utilitarna perspektiva, ki jo lahko opazimo pri 51 (62,9%) obravnavanih prispevkih. Od leta 2004 se je zaradi diverzifikacije možnosti medijskega poročanja povečalo število objavljenih člankov o* H. griseus*. V Turčiji imajo ljudje vnaprej izoblikovano predstavo o morskih psih, ki se je v letih neodgovornega medijskega poročanja trdno zasidrala v njihovi zavesti. Članki, ki morskega psa šesteroškrgarja prikazujejo kot možen vir zaslužka, lahko ribiče vzpodbudijo k lovu na to občutljivo vrsto in povzročijo umeten ribolovni pritisk na* H. griseus*.*

**Ključne besede**: morski pes šesteroškrgar, *Hexanchus griseus,* Turčija, prikaz, mediji, varstvo

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# MORPHOLOGICAL ABNORMALITIES IN TWO BATOID SPECIES (CHONDRICHTHYES) FROM NORTHERN TUNISIAN WATERS (CENTRAL MEDITERRANEAN)

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## *ABSTRACT*

*The authors present two cases of abnormalities recorded in two elasmobranch species from northern Tunisian waters. A pregnant common torpedo* Torpedo torpedo *captured in the Lagoon of Bizerte in northern Tunisia, carried three embryos, two of which, one female and one male, were abnormal, both having the pectoral fin non-adherent to the head. A juvenile female* Raja polystigma *captured off northern coast of Tunisia presented a morphological abnormality at distal end of tail in the shape of a fork. These two cases of abnormalities are described, commented and discussed.*

**Key words:** Chondrichthyes, *Torpedo torpedo*, *Raja polystigma*, morphological abnormalities, Lagoon of Bizerte, central Mediterranean

# ANOMALIE MORFOLOGICHE IN DUE SPECIE BATOIDI (CHONDRICHTHYES) DI ACQUE SETTENTRIONALI DELLA TUNISIA (MEDITERRANEO CENTRALE)

## *SINTESI*

*Gli autori presentano due casi di anomalie riscontrate in due specie di elasmobranchi di acque settentrionali della Tunisia. Una femmina gravida di torpedine ocellata* Torpedo torpedo, *catturata nella Laguna di Biserta (Tunisia settentrionale), portava tre embrioni dei quali due, una femmina ed un maschio, presentavano anomalie, ossia la pinna pettorale non aderente alla testa. Una giovane femmina di* Raja polystigma *catturata al largo della costa settentrionale della Tunisia presentava un'anomalia morfologica all'estremità distale della coda, ossia una forca. Nell'articolo questi due casi di anomalie vengono descritti, commentati e discussi.*

**Parole chiave:** Chondrichthyes, *Torpedo torpedo*, *Raja polystigma*, anomalie morfologiche, Laguna di Biserta, Mediterraneo centrale

## INTRODUCTION

Morphological abnormalities also called 'monstrosities' by authors were reported in fish species and listed by Dawson (1964, 1966, 1971) and Dawson & Heal (1971). It appears that such phenomena are more frequently recorded in osteichthyan species than in chondrichthyan species. It is probably due to the low commercial value that has characterized the latter for several years and difficulties to obtain a significant number of specimens to detect abnormalities (Hoenig & Walsh, 1983; Ribeiro-Prado *et al.*, 2008). Additionally, they represent a minor group in term of captures, 0.85% of total world captures (Vannucini, 1988).

Morphological abnormalities were listed in sharks (Barrull *et al.*, 2002; Saïdi *et al.*, 2005; Mancini *et al.*, 2006), but also in skates and rays (Ribeiro-Prado *et al.*, 2008; El Kamel *et al.*, 2009a), for both embryos and free-swimming specimens. Morphological abnormalities concern skeleton, chondrodranium and vertebral column in the former, while in the latter they concern fins, mainly pectoral fins. Investigations conducted from early 2006 to date in northern Tunisian waters to establish elasmobranch monitoring in the area allowed the capture of a pregnant female of the common torpedo *Torpedo torpedo* Linnaeus, 1758 carrying abnormal embryos, and an abnormal female of the speckled ray *Raja polystigma* Regan, 1923. Both specimens are described in the present paper, together with comments and a discussion on morphological abnormalities reported in batoid species.

## MATERIAL AND METHODS

Investigations were conducted from June 2006 to October 2010 in northern Tunisian waters, including the northern Tunisian coast from Algerian border (8°37′ E) to Kelibia (11°03′ E), and the Lagoon of Bizerte (Fig. 1). The latter is a brackish water area located in northeastern Tunisia, between 37°8′ and 37°14′ N, and between 9°46′ and 9°56′ E (Fig. 2), where elasmobranch species are regularly caught by gill-nets, longlines or trammel nets (El Kamel *et al.*, 2009b, c).

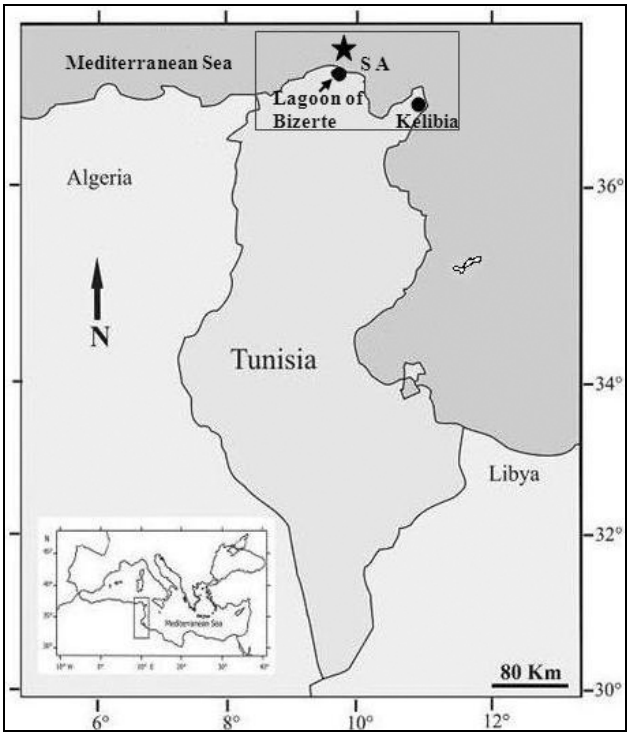


***Fig. 1: Map of the Mediterranean showing the Lagoon of Bizerte, the sampling area (SA) off northern Tunisian coast and pointing out the capture site (black star) of the abnormal*** *Raja polystigma* ***(FSB-Raj-pol-01).***
***Sl. 1: Zemljevid Sredozemlja z Laguno Bizerte, območjem vzorčenja (SA) ob severni tunizijski obali in označeno točko ulova (črna zvezda) abnormalnega primerka vrste*** *Raja polystigma* ***(FSB-Raj-pol-01).***

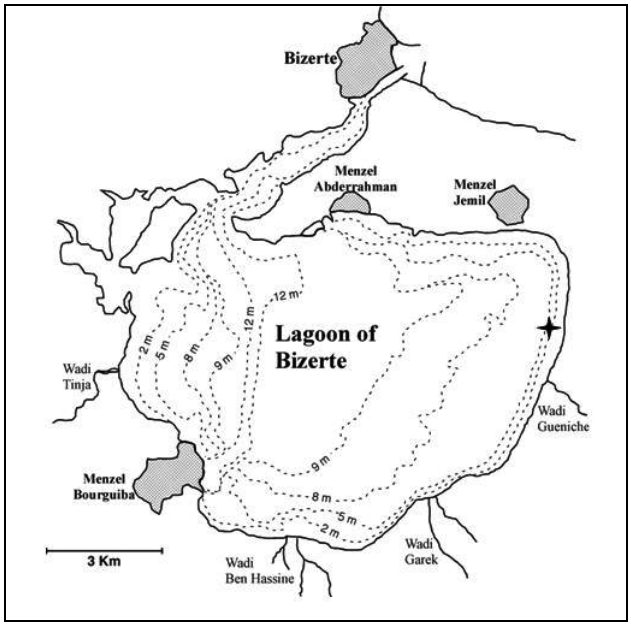


***Fig. 2: Map of the Lagoon of Bizerte showing the capture site (black star) of the pregnant common torpedo,*** *Torpedo torpedo*, ***(FSB T-torp.04).***
***Sl. 2: Zemljevid Lagune Bizerte z označeno točko ulova (črna zvezda) breje samice navadnega električnega ската,*** *Torpedo torpedo*, ***(FSB T-torp.04).***

Soon after captures and identification, both specimens were photographed and measured. Morphometric measurements were recorded to the nearest millimetre following Mejri *et al.* (2004) and masses to the nearest decigram. They were preserved in 5% buffered formalin, deposited in the Ichtyological Collection of the Faculté des Sciences de Bizerte and received catalogue number.

## RESULTS AND DISCUSSION

### Torpedo torpedo

*Torpedo torpedo* is known off the eastern Atlantic from the Bay of Biscaye (Quéro *et al.*, 2003) to the Gulf of Guinea (Blache *et al.*, 1970), and southward to South African waters (Smith & Heemstra, 1986). *T. torpedo* is reported throughout the Mediterranean Sea, but it is more common in southern areas (Capapé, 1989). The species is reported off the Tunisian coast (Bradaï *et al.*, 2004), but it was also recorded in Tunisian brackish areas such as the Bahiret El Biban (Capapé *et al.*, 2004), Tunis Southern Lagoon (Mejri *et al.*, 2004) and the Lagoon of Bizerte where a sustainable population has probably found favourable environmental conditions to develop and reproduce (El Kamel *et al.*, 2009b, c).

On 21 July 2010, a female *T. torpedo* was captured by commercial gill-nets at 1.5–2.5 m, on sandy-muddy bottom in the Lagoon of Bizerte, at 37°12′23" N and 9°56′86" E. It was 275 mm in total length and weighed 361.8 g in total mass, while the eviscerated body mass reached 313.4 g. The female was dissected soon after its capture and the uteri contained 3 embryos which were removed and analysed; two of them presented morphological abnormalities, one was normal. The pregnant female was referenced FSB T-torp.04, while the 3 embryos FSB T-torp.05, FSB T-torp.06 and FSB T-torp.07. Morphometric measurements were carried out in the 4 specimens and are presented in Table 1.

The first abnormal embryo (FSB T-torp.05) was a male having 70 mm in total length and weighting 4.69 g. The left pectoral fin was non-adherent to the head and a large region of the fin was missing. The pectoral fin was constituted by a short curve ending by a distal point. Additionally, a large region of the left pelvic fin was also missing and less developed that the right pelvic fin (Fig. 3). The second abnormal embryo (FSB T-torp.06) was a female smaller than the abnormal male; its total length was 52.16 mm and it weighed 1.96 g. The right pectoral fin of this embryo presented a slight non-adherence to the head while the right pelvic fin was not completely formed and smaller than the left pectoral fin (Fig. 4).

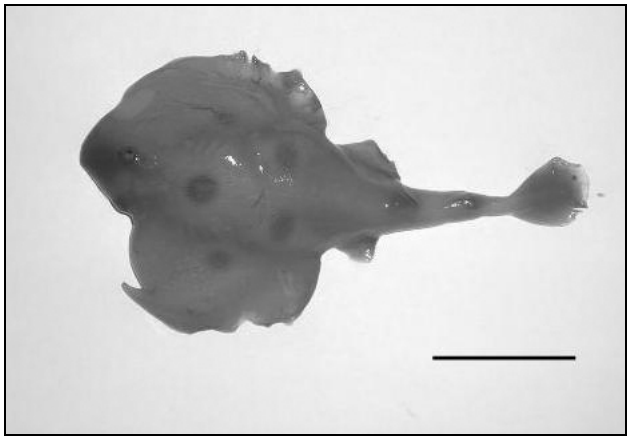

***Fig. 3: Abnormal embryo (FSB T-torp.05), removed from a pregnant female*** *T. torpedo****, scale bar = 20 mm.***
***Sl. 3: Abnormalni zarodek (FSB T-torp.05), odstranjen iz breje samice vrste*** *T. torpedo****, merilo = 20 mm.***

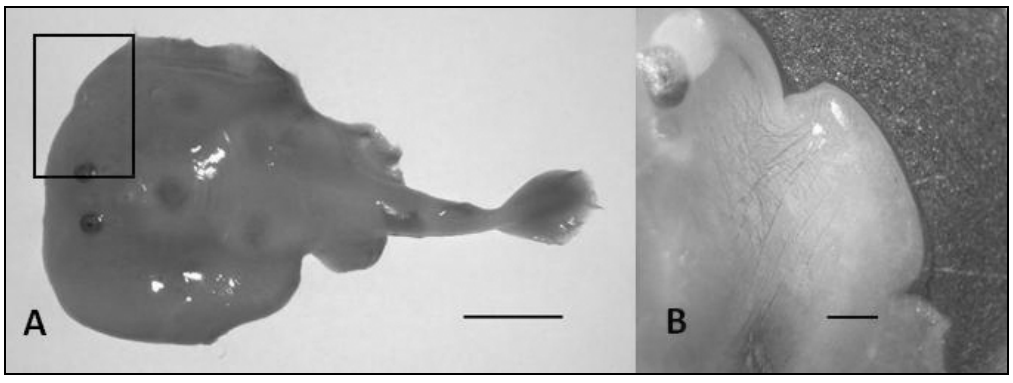


***Fig. 4: A. Abnormal embryo (FSB T-torp.06), removed from a pregnant female*** *T. torpedo* ***scale bar= 10 mm. B. Insert showing the pectoral non-adherent to the head, scale bar = 2 mm.***
***Sl. 4: A. Abnormalni zarodek (FSB T-torp.06), odstranjen iz breje samice vrste*** *T. torpedo****, merilo = 10 mm. B. Izsek prikazuje prsno plavut, ki se ne stika z glavo, merilo = 2 mm.***

***Tab. 1: Morphometric measurements and meristic counts recorded in the pregnant common torpedo (FSB T-torp.04), and its uterine content: two abnormal embryos (FSB T-torp.05 and FSB T-torp.06) and a normal embryo (FSB T-torp.07).***

***Tab. 1: Morfometrični in meristični podatki za brejo samico navadnega električnega skata (FSB T-torp.04) in tri zarodke: dva abnormalna (FSB T-torp.05 and FSB T-torp.06) in en normalen zarodek (FSB T-torp.07).***

| **Reference** | **FSB T-torp.04** | | **FSB T-torp.05** | | **FSB T-torp.06** | | **FSB T-torp.07** | |
|---|---|---|---|---|---|---|---|---|
| **Sex** | **F** | | **M** | | **F** | | **F** | |
| **Total mass (g)** | 361.80 | | 4.69 | | 1.96 | | 5.07 | |
| **Measurements** | mm | % TL | mm | % TL | mm | % TL | mm | % TL |
| Total length (TL) | 275.00 | | 70.76 | | 52.16 | | 68.58 | |
| Disc length | 140.00 | 50.91 | 36.72 | 51.89 | 25.42 | 48.73 | 32.39 | 47.23 |
| Disc width | 175.00 | 63.64 | 39.35 | 55.61 | 28.76 | 55.14 | 39.31 | 57.32 |
| Disc depth | 22.98 | 8.36 | 5.43 | 7.67 | 4.58 | 8.78 | 5.14 | 7.49 |
| Eyeball length | 7.65 | 2.78 | 3.24 | 4.58 | 2.36 | 4.52 | 3.00 | 4.37 |
| Cornea | 3.98 | 1.45 | 2.09 | 2.95 | 1.72 | 3.30 | 1.67 | 2.44 |
| Pre-orbital length | 20.52 | 7.46 | 5.64 | 7.97 | 4.44 | 8.51 | 5.89 | 8.59 |
| Inter-orbital width | 11.90 | 4.33 | 5.49 | 7.76 | 2.47 | 4.74 | 3.10 | 4.52 |
| Nasal curtain | 15.58 | 5.67 | 3.95 | 5.58 | 4.36 | 8.36 | 5.05 | 7.36 |
| Spiracle diameter | 5.92 | 2.15 | 2.29 | 3.24 | 1.39 | 2.66 | 1.53 | 2.23 |
| Inter-nasal width | 12.89 | 4.69 | 3.56 | 5.03 | 3.58 | 6.86 | 3.68 | 5.37 |
| Space between eye and spiracle | 7.36 | 2.68 | 2.30 | 3.25 | 1.92 | 3.68 | 1.11 | 1.62 |
| Inter-spiracular width | 13.93 | 5.07 | 6.91 | 9.77 | 4.72 | 9.05 | 4.99 | 7.28 |
| Pre-oral length | 24.73 | 8.99 | 7.95 | 11.24 | 3.51 | 6.73 | 6.17 | 9.00 |
| Mouth width | 17.03 | 6.19 | 5.07 | 7.17 | 4.23 | 8.11 | 4.56 | 6.65 |
| First gill slit | 5.99 | 2.18 | 1.27 | 1.79 | 1.14 | 2.19 | 1.52 | 2.22 |
| Second gill slit | 6.45 | 2.35 | 1.56 | 2.20 | 1.45 | 2.78 | 1.52 | 2.22 |
| Third gill slit | 7.14 | 2.60 | 2.01 | 2.84 | 1.90 | 3.64 | 1.83 | 2.67 |
| Fourth gill slit | 7.38 | 2.68 | 1.82 | 2.57 | 0.45 | 0.86 | 1.90 | 2.77 |
| Fifth gill slit | 4.81 | 1.75 | 1.03 | 1.46 | 1.52 | 2.91 | 0.98 | 1.43 |
| Width between first gill slit | 41.74 | 15.18 | 11.35 | 16.04 | 5.31 | 10.18 | 9.39 | 13.69 |
| Width between first gill slit | 36.98 | 13.45 | 10.16 | 14.36 | 4.49 | 8.61 | 9.58 | 13.97 |
| Snout tip to eye | 21.59 | 7.85 | 7.05 | 9.96 | 5.67 | 10.87 | 7.21 | 10.51 |
| Snout tip to mouth | 26.83 | 9.76 | 8.11 | 11.46 | 5.44 | 10.43 | 7.02 | 10.24 |
| Snout tip to first gill slit | 59.18 | 21.52 | 12.94 | 18.29 | 7.22 | 13.84 | 10.07 | 14.68 |
| Snout tip to fifth gill slit | 83.22 | 30.26 | 18.84 | 26.63 | 16.37 | 31.38 | 17.48 | 25.49 |
| Snout tip pelvic fin | 143.00 | 52.00 | 36.91 | 52.16 | 24.66 | 47.28 | 32.03 | 46.70 |
| Snout tip to vent | 162.00 | 58.91 | 38.86 | 54.92 | 27.38 | 52.49 | 37.15 | 54.17 |
| Pectoral fin anterior margin | 70.28 | 25.56 | 25.04 | 35.39 | 16.52 | 31.67 | 16.81 | 24.51 |
| Pectoral fin posterior margin | 91.53 | 33.28 | 17.77 | 25.11 | 15.52 | 29.75 | 18.91 | 27.57 |
| Pectoral fin inner margin | 11.24 | 4.09 | 2.03 | 2.87 | 3.25 | 6.23 | 1.70 | 2.48 |
| Pelvic fin anterior margin | 36.15 | 13.15 | 10.14 | 14.33 | 5.60 | 10.74 | 6.79 | 9.90 |
| Pelvic fin posterior margin | 54.55 | 19.84 | 10.77 | 15.22 | 7.07 | 13.55 | 12.51 | 18.24 |
| Pelvic fin inner margin | 10.69 | 3.89 | 3.13 | 4.42 | 2.21 | 4.24 | 2.39 | 3.48 |
| Span of pelvic fins | 85.67 | 31.15 | 19.03 | 26.89 | 13.88 | 26.61 | 17.47 | 25.47 |
| Tail base width | 25.57 | 9.30 | 7.15 | 10.10 | 4.26 | 8.17 | 6.02 | 8.78 |
| Tail base depth | 15.26 | 5.55 | 3.25 | 4.59 | 2.27 | 4.35 | 3.47 | 5.06 |
| Tail length | 101.35 | 36.85 | 24.87 | 35.15 | 19.68 | 37.73 | 24.82 | 36.19 |
| Snout tip to first dorsal | 178.00 | 64.73 | 43.65 | 61.69 | 29.37 | 56.31 | 41.50 | 60.51 |
| Snout tip to second dorsal | 215.00 | 78.18 | 52.34 | 73.97 | 34.66 | 66.45 | 49.31 | 71.90 |
| Snout tip to birth of dorsal ca udal | 245.00 | 89.09 | 60.53 | 85.54 | 43.13 | 82.69 | 55.12 | 80.37 |
| Snout tip to birth of ventral ca udal | 240.00 | 87.27 | 59.41 | 83.96 | 42.31 | 81.12 | 55.48 | 80.90 |
| Caudal superior | 44.58 | 16.21 | 12.68 | 17.92 | 7.20 | 13.80 | 12.98 | 18.93 |
| Caudal inferior edge | 37.03 | 13.47 | 11.63 | 16.44 | 7.43 | 14.24 | 8.69 | 12.67 |
| Caudal posterior edge | 47.48 | 17.27 | 10.55 | 14.91 | 5.96 | 11.43 | 9.52 | 13.88 |
| First dorsal anterior edge | 35.57 | 12.93 | 6.78 | 9.58 | 2.98 | 5.71 | 3.20 | 4.67 |
| First dorsal posterior edge | 23.33 | 8.48 | 4.40 | 6.22 | 3.36 | 6.44 | 4.82 | 7.03 |
| First dorsal inner edge | 6.59 | 2.40 | 4.31 | 6.09 | 2.28 | 4.37 | 2.77 | 4.04 |
| First dorsal base | 18.80 | 6.84 | 4.17 | 5.89 | 3.93 | 7.53 | 4.00 | 5.83 |
| Second dorsal anterior edge | 25.14 | 9.14 | 4.20 | 5.94 | 42.87 | 82.19 | 3.93 | 5.73 |
| Second dorsal posterior edge | 16.40 | 5.96 | 4.00 | 5.65 | 2.78 | 5.33 | 3.40 | 4.96 |
| Second dorsal inner edge | 5.87 | 2.13 | 2.73 | 3.86 | 2.12 | 4.06 | 2.25 | 3.28 |
| Second base | 12.76 | 4.64 | 3.84 | 5.43 | 3.06 | 5.87 | 3.53 | 5.15 |
| Inter-dorsal distance | 14.60 | 5.31 | 3.60 | 5.09 | 2.69 | 5.16 | 3.95 | 5.76 |
| Second dorsal to caudal birth | 13.65 | 4.96 | 3.64 | 5.14 | 3.13 | 6.00 | 4.20 | 6.12 |
| Caudal careen | 40.48 | 14.72 | 11.36 | 16.05 | 7.48 | 14.34 | 11.83 | 17.25 |
| Clasper length | - | | 5.82 | 8.22 | - | | - | |

***Tab. 2: Morphological abnormalities recorded in the ichthyological literature in specimens of the genus** Torpedo.*
***Tab. 2: Morfološke nepravilnosti, zabeležene v ihtiološki literaturi pri primerkih iz rodu** Torpedo.*

| Species | Case of abnormality | Marine region | Authors |
|---|---|---|---|
| *T. marmorata* | Pectoral non adherent to the head | Adriatic Sea | Valle (1931) |
| *T. marmorata* | Pectoral non adherent to the head | Adriatic Sea | Jardas & Homen (1977) |
| *T. nobiliana* | Pectoral non adherent to the head | Atlantic Ocean | Palmer & Wheeler (1958) |
| *T. torpedo* | Surnumerary dorsal fin | Lagoon of Bizerte | Ben Brahim & Capapé (1997) |
| *T. torpedo* | Lack of gill-slit | Lagoon of Bizerte | El Kamel *et al.* (2009a) |
| *T. torpedo* | Pectoral non adherent to the head | Lagoon of Bizerte | This study |
| *T. torpedo* | Pectoral non adherent to the head | Lagoon of Bizerte | This study |

The atypical morphological characteristics observed in the embryos carried by the pregnant female *T. torpedo* were pectoral fins non-adherent to the head, rarely recorded in torpedinid species (Ribeiro-Prado *et al.*, 2008). Three cases were recorded to date in free swimming specimens (Tab. 2), two for the marbled electric ray *Torpedo marmorata* Risso, 1810 and a single case for the black torpedo *Torpedo nobiliana* Bonaparte, 1835. Consequently, such abnormality was reported herein for the first time in the common torpedo. However, it was found in developing embryos; the question is whether their development would complete and if they would be able to live in the wild after birth. It could explain why no free swimming common torpedos presenting similar abnormality were found to date. In contrast Ribeiro-Prado *et al.* (2008) listed 24 similar cases in rajid species and 11 cases in stingrays. This relatively frequent occurrence of abnormalities in this species rather than in torpedinids appears difficult to explain. It may be due to sampling, but also to disk shape, rectangular in skates and rays, rounded in torpedos; it could mean that it is more difficult for pectoral fins to develop adherent to the head in the former than in the latter.

According to Bigelow & Schroeder (1953), such morphological abnormality occurs when the pectoral fins fail to fuse together in front of the head in early development. Additionally, Thorson *et al.* (1983) described embryonic development in the two freshwater stingrays *Potamotrygon constellata* (Vaillant, 1880) and *P. motoro* (Müller & Henle, 1841) as follows: in early embryos, the stingray's pectoral fins begin to separate, then fuse in medium embryos and finally form the complete disc in near term embryos.

Three common torpedos presenting abnormalities were reported from the Lagoon of Bizerte (see Table 2, Ben Brahim & Capapé, 1997; Ben Brahim *et al.*, 1998). This relatively high frequency could be explained by the pollution, affecting a restricted brackish area such as the Lagoon of Bizerte, polluted by both inorganic and organic nutriments and heavy metals. The common torpedo lives buried in sandy bottoms (El Kamel *et al.*, 2009a, b, c), where pollutants are collected (Mzoughi *et al.*, 2002; Harzallah, 2003). However, this hypothesis needs further confirmation.

**Raja polystigma**

The speckled ray *Raja polystigma* Regan, 1923 is probably endemic to the Mediterranean Sea (Capapé, 1989), and up to date, unknown off the eastern side of the Atlantic (Quéro *et al.*, 2003). The species was reported in northern Mediterranean areas, such as the Catalan Sea (Matallanas, 1977), southern France (Capapé *et al.*, 2006a, b), the Italian Seas (Tortonese, 1956; Arbocco, 1966), off Greece (Kaspiris, 1974). Southward, *R. polystigma* is known off the Maghreb shore, Morocco (Lloris & Rucabado, 1998), Algeria (Hemida *et al.*, 2007), Tunisia, where the species is rather common in northern areas (Capapé *et al.*, 1980; Bradaï *et al.*, 2004).

On 25 May 2010, a speckled ray was captured off northern coast of Tunisia by trawler (37°31'9.36" N; 9°51'26.71" E), at depth between cca. 150 and 200 m, on sandy-muddy bottom (Fig. 5). The specimen of *R. polystigma* was identified following Clark (1926), Tortonese (1956) and Capapé *et al.* (1980, 2006b), as follows: disc sub-quadrangular, obtuse in front, with snout rounded, anterior margin slightly concave at level of eyes and outer corners; outer angles broadly rounded; posterior margins convex; first dorsal larger than second dorsal. Disc depth 11%, disc length 77.8%, pre-oral length 15.9%, pelvic span 37%, pelvic fin anterior margin all in disc width (DW). Dorsal surface greyish--brownish with dark and yellowish spots, belly beige with the outer margin of disc slightly brownish. Additional morphological measurements and meristic counts (see Table 3) are in agreement with those reported by these authors.

The specimen was 374 mm DW, 541 mm total length, the total body mass and the eviscerated body mass were 1104.3 g and 921 g, respectively, while the liver mass was 38.7 g. The gonads were thread-like and both weighed 5.2 g, the oviducal glands were inconspicuously developed and both weighed 0.94 g. The specimen was still juvenile, in agreement with Capapé & Quignard (1978) who noted that females over 400 mm DW were mature. The gut was empty, with no food or remains of food.

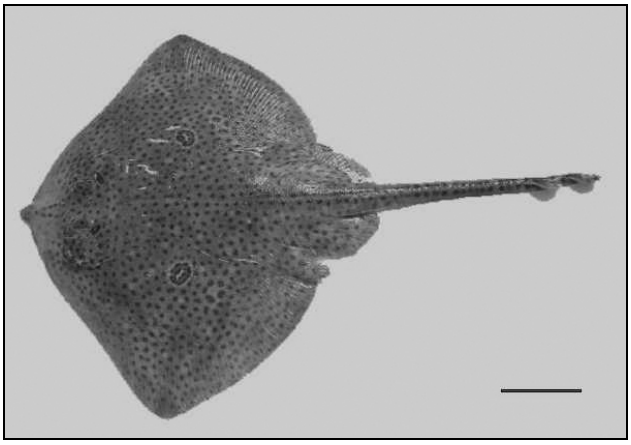

***Fig. 5: Abnormal** R. polystigma **caught off northern Tunisian coast, scale bar = 50 mm.***
***Sl. 5: Abnormalni primerek vrste** R. polystigma**, ujet ob severni tunizijski obali, merilo = 50 mm.***

However, the specimen presented a morphological abnormality at distal end of tail in the shape of a fork (Fig. 6). This morphological abnormality in tail is not due to an injury as it is generally the case in skates (see Mnasri *et al.*, 2009). No scar was visible in this fork which is also covered by pigmented skin. To our knowledge, it is the first time that such abnormality was recorded to date in skates. Ribeiro-Prado *et al.* (2008) listed all morphological abnormalities recorded to date in skates and rays, and noted that abnormalities occurred in disc, with pectoral fins non-adherent to the head being the most recorded one. The latter not only concerned skates but also rays and rarely torpedinids. A single case of abnormality reported to date was in a rough ray *Raja radula* Delaroche, 1809 by Capapé & Pantoustier (1975). Another case of morphological abnormality in tail was observed in a common torpedo *T. torpedo* in Tunisian waters, the specimen exhibiting a surnumerary dorsal fin (Ben Brahim & Capapé, 1997).

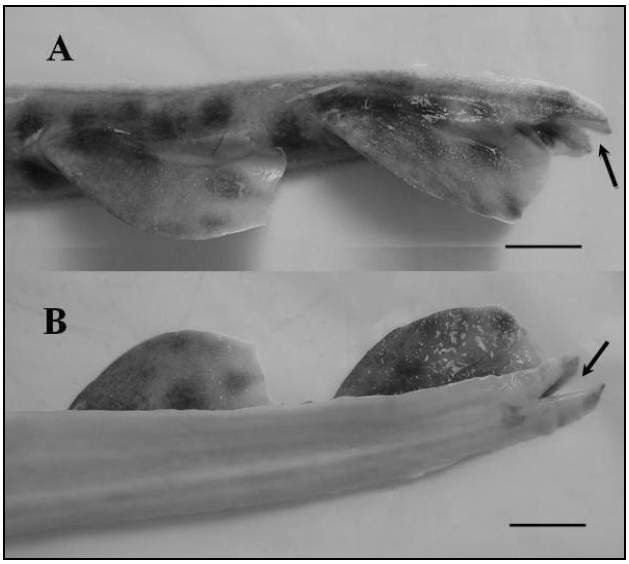


***Fig. 6: Tail of abnormal** R. polystigma **with black arrow pointing out the morphological abnormality or fork, scale bar = 10 mm. (A) Dorsal surface, (B) ventral surface.***
***Sl. 6: Rep abnormalnega primerka vrste** R. polystigma **s črno puščico, ki kaže na morfološko deformacijo v obliki škarjastega repa, merilo = 10 mm. (A) Hrbtna stran, (B) trebušna stran.***

Literature review shows that cases of abnormalities are relatively rare in elasmobranch species (see Dawson, 1964, 1966, 1971; Dawson & Heal, 1971; Hoenig & Walsh, 1983; Ribeiro-Prado *et al.*, 2008). However, the percentage of abnormalities recorded is not representative of the real number of cases, because all specimens came from fisheries. So, in order to obtain a more accurate percentage, samples from scientific surveys should be considered.

The causes of such abnormalities remain doubtful and still hypothetical. Unfavourable environmental conditions, such as large exposures to pollutants for instance, probably play a role in occurrence of abnormalities (Ribeiro-Prado *et al.*, 2008). It could explain why abnormalities are more often observed in oviparous species than in viviparous species; in the former, embryos develop in egg cases directly deposited in water, while in the latter embryos are protected in the mother's uteri (Casarini *et al.*, 1996). However, we cannot totally exclude the role of the polluted environment in abnormalities observed in viviparous elasmobranch species. Some instances were reported herein concerning the common torpedo from the Lagoon of Bizerte. Bensam (1965) noted that embryonic deformities could be caused by intrauterine pressure exerted by other embryos in a same litter. In contrast, Bonfil (1989) argues that in a litter, embryos are exposed to the same space and growth conditions, so the origin of pre-natal abnormalities would be related to mutation or other developmental irregularities. Rosa *et al.* (1996) noted that abnormalities could be due to disturbance in the initial stages of ontogeny known as shark stage, where embryos have fins separated from the head, resembling shark embryos.

According to Rosa *et al.* (1996) the fact that adult skates exhibiting abnormalities occur alive and in good condition, means that these deformities do not interfere with the biological activities, mainly feeding. Additionally, an interesting instance was described by Oldfield (2005) of a female ocellated freshwater stingray *P. motoro* placed in captivity, which gave birth to a couple of abnormal specimens. Oldfield (2005) noted that the first specimen died two days after birth, while the second specimen born as a 'Batman ray' did fantastic, eating

***Tab. 3: Morphometric measurements and meristic counts recorded in the abnormal** Raja polystigma **(FSB-Raj-pol-01).***
***Tab. 3: Morfometrični in meristični podatki za abnormalnem primerek vrste** Raja polystigma **(FSB-Raj-pol-01).***

| **Reference** | **FSB-Raj-pol-01** | |
|---|---|---|
| **Morphometric measurments** | mm | % DW |
| Total length | 541 | 144.6 |
| Disc length | 291 | 77.8 |
| Disc width (DW) | 374 | |
| Disc depth | 41.4 | 11.1 |
| Eyeball length | 18.2 | 4.9 |
| Cornea | 13.1 | 3.5 |
| Pre-orbital length | 59.1 | 15.8 |
| Inter-orbital width | 24.5 | 6.6 |
| Spiracle length | 14.7 | 3.9 |
| Spiracle width | 6.15 | 1.6 |
| Inter-nasal width | 37.2 | 9.9 |
| Nasal curtain | 47.9 | 12.8 |
| Interspiracular width | 35.4 | 9.5 |
| Pre-oral length | 59.6 | 15.9 |
| Mouth width | 47.9 | 12.8 |
| First gill slit | 14.1 | 3.8 |
| Second gill slit | 14.5 | 3.9 |
| Third gill slit | 13.6 | 3.6 |
| Forth gill slit | 13.6 | 3.7 |
| Fifth gill slit | 8.5 | 2.3 |
| Width between first gill slit | 76.5 | 20.4 |
| Width between fifth gill slit | 38.9 | 10.4 |
| Snout tip to eye | 71.3 | 19.1 |
| Snout tip to mouth | 66.1 | 17.7 |
| Snout tip to first gill slit | 103 | 27.5 |
| Snout tip to fifth gill slit | 146 | 39.1 |
| Snout tip to pelvic fin | 230 | 61.5 |
| Snout tip to vent | 254 | 67.9 |
| Pectoral fin anterior margin | 250 | 66.8 |
| Pectoral fin posterior margin | 195 | 52.1 |
| Pectoral fin inner margin | 37.9 | 10.2 |
| Pelvic  fin anterior margin | 57.3 | 15.3 |
| Pelvic  fin posterior margin | 84.6 | 22.6 |
| Pelvic fin inner margin | 31.7 | 8.5 |
| Span of pelvic fin | 142 | 37.97 |
| Tail base width | 28.7 | 7.6 |
| Tail base depth | 17.4 | 4.7 |
| Tail length | 255 | 68.2 |
| Snout tip to first dorsal | 472 | 126.2 |
| Snout tip to second dorsal | 510 | 136.4 |
| Superior caudal edge | 8.8 | 2.4 |
| Inferior caudal edge | 5.9 | 1.6 |
| First dorsal anterior edge | 26 | 6.9 |
| First dorsal posterior edge | 11.8 | 3.1 |
| First dorsal base | 27.9 | 7.5 |
| Second dorsal anterior edge | 25.7 | 6.8 |
| Second dorsal posterior edge | 13.8 | 3.7 |
| Second dorsal base | 25.6 | 6.8 |
| Inter-dorsal distance d1-d2 | 9.1 | 2.4 |
| Third dorsal anterior edge | 7.8 | 2.1 |
| Third dorsal posterior edge | 2.1 | 0.6 |
| Third dorsal base | 5.1 | 1.4 |
| Inter-dorsal distance d2-d3 | 3.9 | 1.1 |
| Third dorsal caudal birth | 0.8 | 0.2 |
| Tooth rows upper jaw | 54 | |
| Tooth rows lower jaw | 57 | |
| Pseudo-branchial lamellae | 16/16 | |
| Nictitating lamellae | 13/13 | |
| Pectoral rays | 75/75 | |
| Truncal vertebrae | 28 | |

healthily, growing rapidly, and developing a nice colour pattern. These observations confirm that such morphological abnormalities do not necessarily play a negative role in embryonic development and beyond, during life in the wild of specimens having the pectoral fin non-adherent to the head.

# MORFOLOŠKE NEPRAVILNOSTI PRI DVEH VRSTAH SKATOV (CHONDRICHTHYES) IZ SEVERNIH TUNIZIJSKIH VODA (OSREDNJE SREDOZEMLJE)

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*POVZETEK*

*Avtorji članka predstavljajo dva primera nepravilnosti, zabeležena pri dveh vrstah skatov iz severnih tunizijskih voda. Breja samica navadnega električnega skata* Torpedo torpedo*, ujeta v Laguni Bizerte v severni Tuniziji, je nosila tri zarodke, od katerih sta bila dva, en ženski in en moški, abnormalna, s prsno plavutjo, ki se ni stikala z glavo. Mladostna samica vrste* Raja polystigma*, ujeta ob severni tunizijski obali, pa je imela abnormalen rep škarjaste oblike. Primera nepravilnosti sta opisana, komentirana in diskutirana.*

**Ključne besede:** Chondrichthyes, *Torpedo torpedo*, *Raja polystigma*, morfološke abnormalnosti, Laguna Bizerte, osrednje Sredozemlje

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# EVALUATION ON THE ECOLOGICAL STATUS OF THE MACROZOOBENTHIC COMMUNITIES IN THE MARANO AND GRADO LAGOON (NORTHERN ADRIATIC SEA)

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## *ABSTRACT*

*The status of the macrozoobenthic community in the Marano and Grado Lagoon was evaluated, according to the application of the Water Framework Directive for the transitional waters. Benthos samplings were carried out in 2008. At forty-two sampled stations 14,522 organisms from 163 taxa were identified. The number of taxa and diversity indexes decreased from inlets towards the inner bank of the lagoon, as a function of a salinity gradient identified with three water types. Multivariate analysis and analysis of benthic biocenoses revealed the existence of three distinct macrozoobenthic communities related to the closeness and/or the proximity of sea. Dominant species resulted to be typical resident of lagoonal environment, accompanied with opportunistic species able to tolerate large variations of chemical and physical parameters in the transitional environments. M-AMBI index assigned the ecological quality status in relation to biodiversity degree.*

**Key words:** macrozoobenthos, Lagoon of Marano and Grado, ecological status, Water Framework Directive, northern Adriatic Sea

# VALUTAZIONE DELLO STATO ECOLOGICO DELLE COMUNITA' MACROZOOBENTONICHE NELLA LAGUNA DI MARANO E GRADO (ADRIATICO SETTENTRIONALE)

## *SINTESI*

*Lo stato ecologico delle comunità macrozoobentoniche della Laguna di Marano e Grado è stato esaminato in applicazione della Direttiva Comunitaria sulle acque superficiali per gli ambienti di transizione. Il macrozoobenthos è stato campionato nel 2008 su 42 stazioni e sono stati identificati 14.522 individui per un totale di 163 taxa. Il numero di taxa e gli indici di diversità hanno presentato valori decrescenti dalle bocche lagunari verso le aree interne della laguna, in funzione del gradiente di salinità identificato nei tre tipi idrici. L'analisi multivariata e l'analisi biocenotica hanno rilevato la presenza di tre distinte comunità bentoniche in relazione alla vicinanza e/o lontananza dal mare. Le specie dominanti sono risultate quelle tipiche degli ambienti lagunari, accompagnate da specie opportuniste capaci di tollerare l'elevata variabilità ambientale degli ambienti di transizione. L'indice M-AMBI ha evidenziato come lo stato di qualità ecologica venga attribuito in funzione del grado di biodiversità.*

**Parole chiave:** macrozoobenthos, Laguna di Marano e Grado, stato ecologico, Direttiva Quadro sulle Acque, Adriatico Settentrionale

## INTRODUCTION

Lagoons are classified as transitional waters sited between marine and continental domains. These systems are brackish or hyperhaline water bodies, separated from sea by barrier islands, formed in transgressional regime due to the presence of abundant terrigenous supplies and significant coastal transports (Brambati, 1988). Until 1950's lagoons, and generally all transitional waters, were classified according to salinity, but the tools employed were quite different. Finally in 1958 the "Venice system" was proposed as a water classification system according to fixed salinity values.

The Water Framework Directive (WFD 2000/60/CE) defines transitional waters as *"all the surface water bodies in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by fresh water flows"*. According to this definition, transitional waters are all ecotones situated between terrestrial, freshwater and marine ecosystems, characterized by high spatial heterogeneity and temporal variability (Basset *et al.*, 2006a). On this basis, transitional waters include fjords, river mouths, deltas, rias, lagoons, coastal ponds and estuaries (McLusky & Elliott, 2007). Transitional waters are heterogeneous and dynamic ecosystems (Gomez *et al.*, 1998; Benedetti-Cecchi *et al.*, 2001) which morphology and hydrology change quickly under the influence of high sedimentation rates, natural coastal dynamics and frequent human activities (Ver *et al.*, 1999; Pastres *et al.*, 2004). These habitats often show high trophic fluxes, broad ranges of chemical and physical parameters with fast biogeochemical cycles (Herbert, 1999; Petihakis *et al.*, 1999; De Wit *et al.*, 2001). In addition, due to their shallow depth and scarce renewal of waters, most of the transitional ecosystems are very vulnerable to eutrophication and chemical pollution (Barnes, 1999), leading to rapid and often unpredictable changes in communities' composition and functioning (Herbert, 1999; Sfriso *et al.*, 2001; Mistri *et al.*, 2002a). The conservation and management of transitional waters requires monitoring activity, integrating chemical and physical evaluation with biological assessment (Gibson *et al.*, 2000; Logan & Furse, 2002).

In shallow water systems, such as lagoons, benthic compartment plays a crucial role controlling the main ecological processes; therefore changes in its structure could affect the whole ecosystem (Snelgrove *et al.*, 1997; Weslawski *et al.*, 2004; Tenore *et al.*, 2006). Due to this, it is possible to estimate the effects of different ecological drivers on the ecosystems' functioning, by analyzing modifications of lagoon benthic communities over time (Pranovi *et al.*, 2008).

The Marano and Grado Lagoon is a part of the lagoon system of the northern Adriatic Sea, stretching between the mouths of the Po and Isonzo rivers (Brambati, 1988). The lagoon, which is located among the Isonzo river to the East and the Tagliamento river to the West, has a total surface area of 160 $km^2$, and extends parallel to the coastline along 32 km (Falace *et al.*, 2009).

Aristocle Vatova has provided most of the main studies and notions dealing with structure of benthic communities in the northern Adriatic lagoons. Since 1930 he studied hydrology, benthic flora and fauna in the Venice Lagoon (Vatova, 1940, 1949), subsequently benthic fauna and productivity of the Marano and Grado Lagoon (Vatova, 1964a, 1964b, 1965). Vatova (1964a) described the general features of the Marano and Grado lagoons, focusing on differences between the two basins. In particular the author measured a lower mean salinity in the Marano Lagoon (21‰) than the Grado Lagoon (26‰) and this difference allowed distinguishing the basins and the related distribution of benthic communities. Benthic fauna of the Marano was in fact poorer than that of Grado, both in term of species and abundance, due to higher freshwater inputs. On the other hand, it was more productive in term of biomass.

The most recent and exhaustive study on macrozoobenthos in the Marano and Grado Lagoon was carried out during a three-year study, from 1993 to 1995 (Orel *et al.*, 2001; Zamboni, 2008). Authors substantially confirmed the observations pointed out by Vatova (1964a): a decreasing gradient of biodiversity was observed moving from the Grado to the Marano, as well as from inlets to inner areas of the lagoon. Orel *et al.* (2001) and Zamboni (2008) identified the zonation of benthos on the basis of confinement degree in the paralic environments as proposed by Guelorgèt & Perthuisot (1983), who defined paralic environments the aquatic ecosystems which have, or had, relation with the sea.

In 1986 the Manila clam (*Tapes philippinarum*) was introduced in the Marano Lagoon for aquaculture purposes. In the time its irrational harvesting with mechanical dredges out of farming areas impacted the benthic community (Orel *et al.*, 2002, 2005). Since 2006 the uncontrolled use of dredges was stopped and manual harvesting is permitted beyond the farming areas.

The aim of the paper was to evaluate the ecological status of the macrozoobenthic community in the Marano and Grado Lagoon, as required by the application in the WFD.

## MATERIAL AND METHODS

The Marano and Grado Lagoon is defined as a coastal microtidal lagoon with large dimensions (Italian Ministry of Environment Decree n.131/08) and the related water types were established as a function of salinity values. In detail, we can discriminate between the mesohaline lagoon (5–20 psu), polyhaline lagoon (20–30 psu) and euhaline lagoon (30–40 psu). Forty-two


***Fig. 1: Study area and sampling stations.***
***Sl. 1: Obravnavano območje in vzorčevalne postaje.***

sampling sites were selected both on the basis of water types, surface and potential gradient of confinement from sea inlets to inner areas (Fig. 1).

Benthic samples were collected with a 0.047 $m^2$ van Veen grab in May 2008. At each station four grabs were taken. The sediment was sieved on a 1 mm mesh and fixed in 4% buffered formaldehyde solution stained with Bengal Rose, and then the fauna was separated and identified to the lowest possible taxonomical level.

Uni- and multivariate techniques were employed to analyze the communities' structure including: abundance, number of taxa, diversity indexes (Shannon-Wiener diversity index (H') on $log_2$ basis (Shannon & Weaver, 1949), Margalef's index (d) (Margalef, 1958) and Pielou's evenness index (J) (Pielou, 1966). The Bray-Curtis similarity coefficient was calculated on square-root transformed data, using complete linkage; subsequently, one-way ANOSIM, K-dominance curves and SIMPER analysis were applied to evaluate similarity and/or differences among groups (PRIMER software package developed at the Plymouth Marine Laboratory).

Bionomic percentage affinity (A%) was calculated by considering characteristic species according to Pérès & Picard (1964). The correction coefficient *C* was first calculated as a percentage of characteristic species of biocenosis *j* respect to the ones of other biocenosis. Then, the absolute affinity of each station was calculated as:

$A_j = n_j\ (100\text{-}C_j)$

where $n_j$ is the number of characteristic species of biocenosis *j* in the considered station. Finally, using a simple proportion, this parameter was expressed as percentage affinity (A%).

A% was calculated for each biocenosis found in the lagoon: Euryhaline and Eurythermal Lagoon biocenosis (LEE French acronym for biocoenose Lagunaire Euryhaline et Eurytherme), fine well-sorted sand biocenosis (SFBC biocoenose des Sables Fins Bien Calibres), superficial muddy sand in sheltered areas biocenosis (SVMC biocoenose des Sables Vaseux Superficiels en Mode Calme), coastal terrigenous muds biocenosis (VTC biocoenose des Vases Terrigenes Cotieres), *Posidonia oceanic*a meadow biocenosis (HP biocoenose de l'Herbier de Posidonies), fine superficial sand biocenosis (SFS biocoenose des Sables Fins Superficiels) and coastal detritical bottoms biocenosis (DC biocoenose des fonds Detritiques Cotiers).

The Bray-Curtis similarity coefficient was calculated on not transformed A% data, using complete linkage. Furthermore RELATE procedure was used to compare clusters derived from abundance and A% data.

***Tab. 1: Average values of number of taxa, abundance, H', d, J and summary of Kruskal-Wallis one-way analysis of variance applied to the water types.***
***Tab. 1: Povprečne vrednosti števila taksonov, številčnosti, H', d, J in povzetek Kruskal-Wallisove enosmerne analize variance na tipih voda.***

| | No. taxa | Abundance (ind./m$^2$) | H' | d | J |
|---|---|---|---|---|---|
| **Euhaline** | 38±14 | 1,775±1,773 | 3.79±0.68 | 6.46±2.00 | 0.74±0.10 |
| **Polyhaline** | 26±8 | 1,937±1,698 | 3.01±0.81 | 4.37±1.19 | 0.65±0.15 |
| **Mesohaline** | 13±4 | 1,711±892 | 2.13±0.50 | 2.06±0.70 | 0.59±0.09 |
| **Kruskal-Wallis (H)** | 18.49 | 0.026 | 16 | 20.2 | 5.23 |
| **p-value** | ≤0.0001 | ≤0.99 | ≤0.0003 | ≤0.0001 | ≤0.073 |
| **df** | 2 | 2 | 2 | 2 | 2 |

AMBI and Biotic Index (BI) were applied (Borja *et al.*, 2000) using the AMBI program (AZTI Marine Biotic Index) (www.azti.es). These indexes are based on the classification of the benthic species in five (I-V) ecological groups (EG), according to their tolerance to pollution (from EG-I = species very sensitive to organic enrichment, intolerant to pollution, EG-II = species indifferent to enrichment, EG-III = species tolerant to enrichment, slightly unbalanced environments, EG-IV = second-order opportunistic species, slight to pronounced unbalanced environments, to EG-V = first-order opportunistic species, pronounced unbalanced environment), then applying an algorithm to calculate the AMBI on a scale of increasing pollution (from 1 to 6) and obtaining the corresponding BI (from 0-1 = unpolluted sites, 2 = slightly polluted, 3 = moderately polluted, 4–5 = moderately to heavily polluted, 6 = heavily polluted to 7 = extremely polluted, azoic state). M-AMBI (Multivariate AMBI) was calculated to assess the ecological quality status (EcoQS): High, Good, Moderate, Poor and Bad according to WFD. This index includes the species richness, Shannon-Wiener diversity and AMBI at the very same time (Muxika *et al.*, 2007). EcoQS was evaluated on the basis of the reference conditions proposed for Italian transitional waters (ISPRA, 2010).

## RESULTS

14,522 organisms from 163 taxa (142 species determined) were identified. Polychaetes were by far the dominant group with 72 species followed by the molluscs (36 species), crustaceans (25 species), echinoderms (6 species) and "other". This latter usually represents scarce groups such as ascidians, anthozoans, sipunculids, nemertines, phoronids, turbellarians and larvae of insects. Taking into consideration the three water types, 147 taxa were recorded in the euhaline water type (16 sampling stations) for a total of 5,339 individuals; 106 taxa were collected in the polyhaline water type (20 sampling stations), for a total of 7,283 individuals and finally 36 taxa in the mesohaline water type (6 sampling stations), for a total of 1,930 individuals.

The percentage abundance of groups was quite proportional in each water type, but the disappearance of echinoderms in the mesohaline lagoon was notable (Fig. 2). Table 1 shows mean values in each water type of the number of taxa, abundance, H', d and J. A clear decreasing gradient from euhaline lagoon to mesohaline basin was significative for taxa, H' and d (Tab. 1); mean abundance did not show any gradient from inlet to inner areas, whereas mean J was decreasing but not in a significative manner.

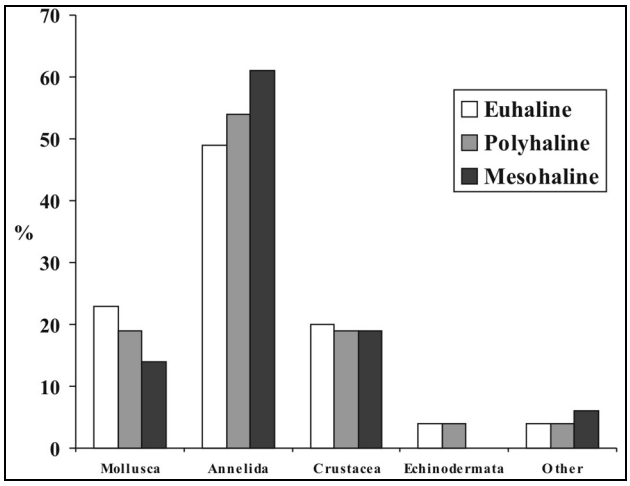


***Fig. 2: Percentage of taxa for different animal phyla detected in euhaline, polyhaline and mesohaline water types.***
***Sl. 2: Delež taksonov za različna živalska debla v evhalinem, polihalinem in mezohalinem tipu vode.***

The dendrogram resulting from the Bray-Curtis similarity matrix showed three different groups tested with one-way ANOSIM (R=0.578; p<0.001): stations close to inlets (group 1), stations among inlets and the inner bank (group 2) and stations closed to the inner bank (group 3) (Fig. 3).

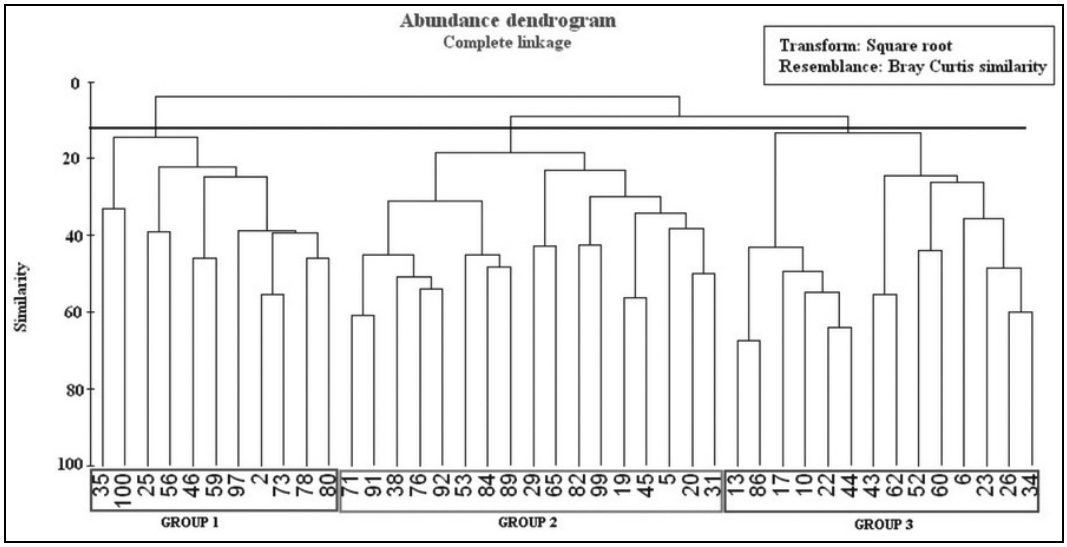


***Fig. 3: Dendrogram obtained by taxa abundance values.***
***Sl. 3: Dendrogram številčnosti taksonov.***

***Tab. 2: Cumulative percentage of dominant taxa in each group revealed by SIMPER analysis.***
***Tab. 2: Kumulativni odstotek dominantnih taksonov v vsaki skupini, ugotovljen s SIMPER analizo.***

| Group | Taxa | Cum. % |
|---|---|---|
| **Paralic group** | *Abra segmentum* | 34.7 |
| | *Hediste diversicolor* | 55.05 |
| | *Streblospio shrubsolii* | 66.94 |
| **Mixed group** | *Chaetozone* sp. | 17.75 |
| | *Abra segmentum* | 34.76 |
| | *Heteromastus filiformis* | 44.91 |
| | *Streblospio shrubsolii* | 53.34 |
| | Oligochaeta indet. | 61.48 |
| **Marine group** | *Minuspio cirrifera* | 12.02 |
| | *Mediomastus capensis* | 21.97 |
| | *Heteromastus filiformis* | 30.16 |
| | *Abra segmentum* | 37.55 |
| | *Pseudoleiocapitella fauveli* | 44.59 |
| | *Capitella capitata* | 51.12 |
| | Oligochaeta indet. | 56.84 |
| | *Myriochele oculata* | 62.1 |

Trend of k-dominance curves identified the community structure in each of the identified groups: group 1, or marine group, with the highest number of species and a quite regular and homogeneous trend; group 3, or paralic group, with higher slope and the lowest number of species; group 2, or mixed group, with an intermediate shape (Fig. 4).

SIMPER analysis identified the mostly involved species in the three groups (Tab. 2). The paralic group was mainly represented by the bivalve *Abra segmentum*, the nereid polychaet *Hediste diversicolor* and the spionid *Streblospio shrubsolii*. The mixed group was characterized by the abundance of the capitellid *Heteromastus filiformis*, the cirratulid *Chaetozone* sp. and oligochaets, in addition to *A. segmentum* and *S. shrubsolii*. The Marine group, in addition to *A. segmentum*, *H. filiformis* and oligochaets, recorded the abundance of the capitellids *Mediomastus capensis*, *Pseudoleiocapitella fauveli*, *Capitella capitata*, the spionid *Minuspio cirrifera* and the owenid *Myriochele oculata*.

Overall, 26 exclusive and preferential species for 7 biocenoses were found (Tab. 3). The dendrogram obtained from the Bray-Curtis similarity matrix applied on A% data, highlighted three groups of stations on the ba-

sis of the different A% values for Eurythermal and Euryhaline biocoenosis (LEE) (Fig. 5): the Paralic group having $A\%_{LEE}$ >65%, the Marine group with $A\%_{LEE}$ <30% and Mixed group 30%< $A\%_{LEE}$ <65%. The RELATE procedure revealed a similarity of the groups identified by two dendrograms (Rho=0.546; p<0.0001).

***Tab. 3: Characteristic species and biocenoses detected in the study area: Euryhaline and Eurythermal Lagoon biocenosis (LEE), fine well-sorted sand biocenosis (SFBC), superficial muddy sand in sheltered areas biocenosis (SVMC), coastal terrigenous muds biocenosis (VTC),*** *Posidonia oceanica* ***meadow biocenosis (HP), coastal detritical bottoms biocenosis (DC) and fine superficial sand biocenosis (SFS).***

***Tab. 3: Značilne vrste in biocenonoze v obravnavanem območju: biocenoza evrihaline in evritermne lagune (LEE), biocenoza na finem sortiranem pesku (SFBC), biocenoza zamuljenih peskov v zaščitenih predelih (SVMC), biocenoza obalnega terigenega mulja (VTC), biocenoza podvodnih travnikov*** *Posidonia oceanica* ***(HP), biocenoza obalnega detritičnega dna (DC) in biocenoza finega površinskega peska (SFS).***

| Characteristic species | Biocenosis |
|---|---|
| *Gibbula adriatica* | LEE |
| *Cerastoderma glaucum* | |
| *Abra segmentum* | |
| *Tapes philippinarum* | |
| *Hediste diversicolor* | |
| *Streblospio shrubsolii* | |
| *Carcinus mediterraneus* | |
| *Nephtys hombergi* | SFBC |
| *Owenia fusiformis* | |
| *Prionospio caspersi* | |
| *Diogenes pugilator* | |
| *Tellimya ferruginosa* | |
| *Thracia papyracea* | |
| *Euclymene oerstedi* | |
| *Upogebia pusilla* | SVMC |
| *Loripes lacteus* | |
| *Tapes decussates* | |
| *Paphia aurea* | |
| *Petaloproctus terricolus* | |
| *Sternaspis scutata* | VTC |
| *Ampharete acutifrons* | |
| *Laonice cirrata* | |
| *Venus verrucosa* | HP |
| *Euclymene lumbricoides* | |
| *Abra prismatica* | DC |
| *Glycera tridactyla* | SFS |

The EcoQS assigned with M-AMBI, was Good for 44% of euhaline stations, Moderate for 38%, Poor for 12% (st. 76 and 100) and Bad for 6% (st. 99) (Fig. 6). In polyhaline type the stations with High status corresponded to 20%, Good to 50%, Moderate to 25% and Poor to 5% (st. 86) (Fig. 6). In the mesohaline type one station (st. 43) was Good, three stations were assessed as Moderate (50%) and two were Poor (st. 13 and 17) (Fig. 6).

The summarizing Table 4 reports M-AMBI as EcoQS, AMBI as disturbance classification and the groups (Marine, Mixed, Paralic) assigned with clusters. The mean number of taxa and average Shannon-Wiener index (H') were calculated for each EcoQS of the water types.

Within the euhaline type (salinity 30-40 psu) all stations with Good ecological quality status possessed Marine characteristics, with 50 identified taxa and H' >4. Stations with Moderate EcoQS possessed normally Mixed characteristics, on average 29 taxa and mean H'=3.5. Stations having Poor EcoQS possessed 33 taxa and H'=2.9: st. 100 had Marine characteristics but a Poor status was assigned probably because of high dominance of oligochaetes, indicating strongly unbalanced conditions. Bad EcoQS was assigned to st. 99, which was very poor in term of taxa. In the polyhaline type (salinity 20-30 psu) only two stations have Marine characteristics (st. 25 and 35), but normally stations showed Mixed or sometimes Paralic conditions. Stations with High EcoQS possessed on average 38 taxa and H'=4. Stations with Good EcoQS had 24 taxa and H'>3. In mesohaline type (salinity 5-20 psu), stations have Paralic conditions, except for st. 43 which is Mixed-Paralic with Good EcoQS (17 taxa, H'=2.5). Disturbance classification detected with AMBI varied from slightly disturbed to moderately disturbed and it seems not linked to water type and cluster groups.

## DISCUSSION

The aim of this study was to characterize the macrozoobenthos living in the Marano and Grado Lagoon, 15 years after the studies carried out in 1993–1995 (Drioli, 1995/1996; Zamboni, 1995/1996; Orel *et al.*, 2001; Zamboni, 2008), and to provide a preliminary application of the WFD 2000/60/CE in this lagoon.

Previously, several authors classified lagoons and coastal ponds as a function of salinity values (Redeke, 1922, 1933; Brunelli, 1933; D'Ancona, 1959). The salinity is a key parameter affecting the biological organization and the expression of biodiversity in Italian lagoons (Basset *et al.*, 2006b) and Greek brackish environments (Reizopoulou & Nicolaidou, 2004). Three water types were identified and analyzed in Marano and Grado according to the actual Italian legislations.

***Tab. 4: Summarizing table.***
***Tab. 4: Pregledna tabela.***

| sampling station | water type | EcoQS (M-AMBI) | No. taxa (mean values) | H′ (mean values) | groups cluster A% | groups cluster abundance | AMBI disturbance classification |
|---|---|---|---|---|---|---|---|
| 46 | EU | GOOD | 50 | 4.4 | Marine | Marine | Slightly |
| 56 | EU | | | | Marine | Marine | Slightly |
| 59 | EU | | | | Marine | Marine | Slightly |
| 73 | EU | | | | Marine | Marine | Moderately |
| 78 | EU | | | | Mixed | Marine | Moderately |
| 80 | EU | | | | Marine | Marine | Moderately |
| 84 | EU | | | | Marine | Mixed | Slightly |
| 29 | EU | MODERATE | 29 | 3.5 | Mixed | Mixed | Slightly |
| 38 | EU | | | | Mixed | Mixed | Moderately |
| 52 | EU | | | | Marine | Paralic | Slightly |
| 89 | EU | | | | Mixed | Mixed | Moderately |
| 92 | EU | | | | Mixed | Mixed | Moderately |
| 97 | EU | | | | Mixed | Marine | Slightly |
| 76 | EU | POOR | 33 | 2.9 | Mixed | Mixed | Moderately |
| 100 | EU | | | | Marine | Marine | Moderately |
| 99 | EU | BAD | 14 | 3 | Mixed | Mixed | Moderately |
| 2 | POLY | HIGH | 38 | 4 | Paralic | Marine | Moderately |
| 23 | POLY | | | | Paralic | Paralic | Slightly |
| 31 | POLY | | | | Mixed | Mixed | Slightly |
| 53 | POLY | | | | Paralic | Mixed | Slightly |
| 5 | POLY | GOOD | 24 | 3.2 | Mixed | Mixed | Slightly |
| 19 | POLY | | | | Mixed | Mixed | Moderately |
| 20 | POLY | | | | Mixed | Mixed | Moderately |
| 26 | POLY | | | | Paralic | Paralic | Moderately |
| 34 | POLY | | | | Mixed | Paralic | Slightly |
| 45 | POLY | | | | Mixed | Mixed | Moderately |
| 60 | POLY | | | | Paralic | Paralic | Slightly |
| 62 | POLY | | | | Mixed | Paralic | Slightly |
| 65 | POLY | | | | Mixed | Mixed | Moderately |
| 71 | POLY | | | | Mixed | Mixed | Moderately |
| 6 | POLY | MODERATE | 22 | 2.2 | Paralic | Paralic | Moderately |
| 25 | POLY | | | | Marine | Marine | Slightly |
| 35 | POLY | | | | Marine | Marine | Moderately |
| 82 | POLY | | | | Paralic | Mixed | Moderately |
| 91 | POLY | | | | Mixed | Mixed | Moderately |
| 86 | POLY | POOR | 10 | 1.6 | Paralic | Paralic | Slightly |
| 43 | MESO | GOOD | 17 | 2.5 | Mixed | Paralic | Slightly |
| 10 | MESO | MODERATE | 14 | 2.4 | Paralic | Paralic | Slightly |
| 22 | MESO | | | | Paralic | Paralic | Slightly |
| 44 | MESO | | | | Paralic | Paralic | Moderately |
| 13 | MESO | POOR | 9 | 1.6 | Paralic | Paralic | Slightly |
| 17 | MESO | | | | Paralic | Paralic | Slightly |

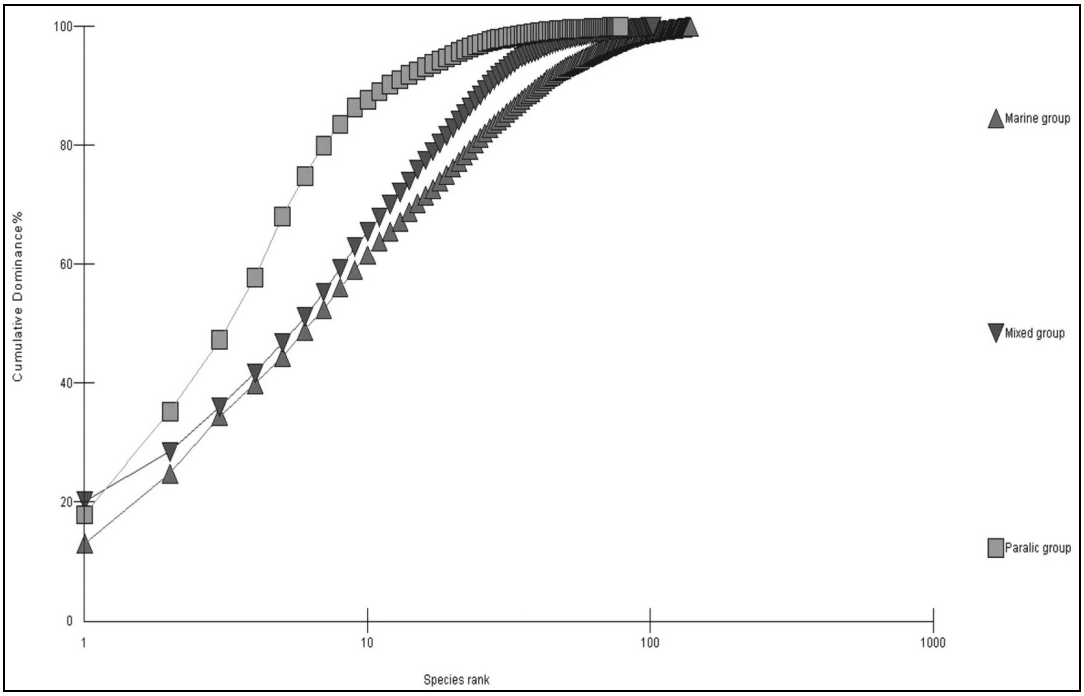


***Fig. 4: K-dominance curves relative to three different groups detected by dendrogram.***
***Sl. 4: Krivulje K-dominance za tri različne skupine, ugotovljene z dendrogramom.***

The Marano Lagoon is embedded in the inland, coupled to a less marine water exchange and very abundant freshwater inputs from Stella, Corno and Aussa rivers (Fig. 1); on the contrary the Grado Lagoon is characterized by scarce freshwater inputs and a wider exchange of marine water. The subdivision of the whole basin into three water types reflects quite well the previous observations of Vatova (1964a, 1964b, 1965) and more recently those of Orel *et al.* (2001) and Zamboni (2008). During 2008 taxa richness, diversity and evenness indices showed high values particularly in nearby inlets. In these areas Shannon-Wiener index (H') was >4, which can be considered a very high value for soft bottom macrozoobenthic communities (Gray, 2000). Therefore high indices values and relevant number of species recorded in 2008 (163 taxa) compared to the 90's, (85 taxa in the three years; Zamboni, 2008), could indicate the increasing richness of taxa in the Marano and Grado Lagoon during the last 15 years. The number of taxa decreased moving from the inlets towards the inner bank of the lagoon, as described also in previous studies. On the contrary, abundance did not show any distribution gradient. On the whole, the partition of benthos into three salinity bands was confirmed by a decreasing diversity from the inlets towards the inner bank. Due to this, a monitoring program based on water types is fully supported by observations carried out in the first studies (Vatova, 1964a, 1965; Orel *et al.*, 2001; Zamboni, 2008) and the 2008 survey.

Guelorgèt & Perthuisot (1982, 1983, 1992) referred on the existence of peculiar euryhaline species. This feature was previously emphasized by Pérès & Picard (1964), who defined the Euryhaline and Eurythermal Lagoon biocenosis. This biocenosis is typical of unstable environments where higher or lower salinity and/or wider salinity and temperature variations occur during the year. This peculiarity is mainly due to river floods, rainfalls and high summer rate of evaporation. Moreover, living communities are able to recover rather quickly their original structures when environmental disturbances and/or dystrophic crisis occur. Due to this great resilience, rather than stability of the communities, paralic environments prevail. The previously mentioned peculiar characteristics of the communities led Guelorgèt & Perthuisot (1982, 1983, 1992) to divide the paralic domain into two subsets. The first one as near paralic, close to the inlets and with chemical-physical parameters similar to sea, whereas the second one as far paralic, farther from sea with chemical-physical parameters deeply different to marine domain. As previously discussed, the salinity is considered a key parameter determining a transition gradient from a typical marine community to a freshwater one. In fact, the fresh/marine waters exchange and circulation play an important role in the dynamics of a lagoon. In this way, hydrology is the fundamental factor conditioning any lagoon environment. In the same context Guelorgèt & Perthuisot (1992) defined the confinement as the time of renewal of

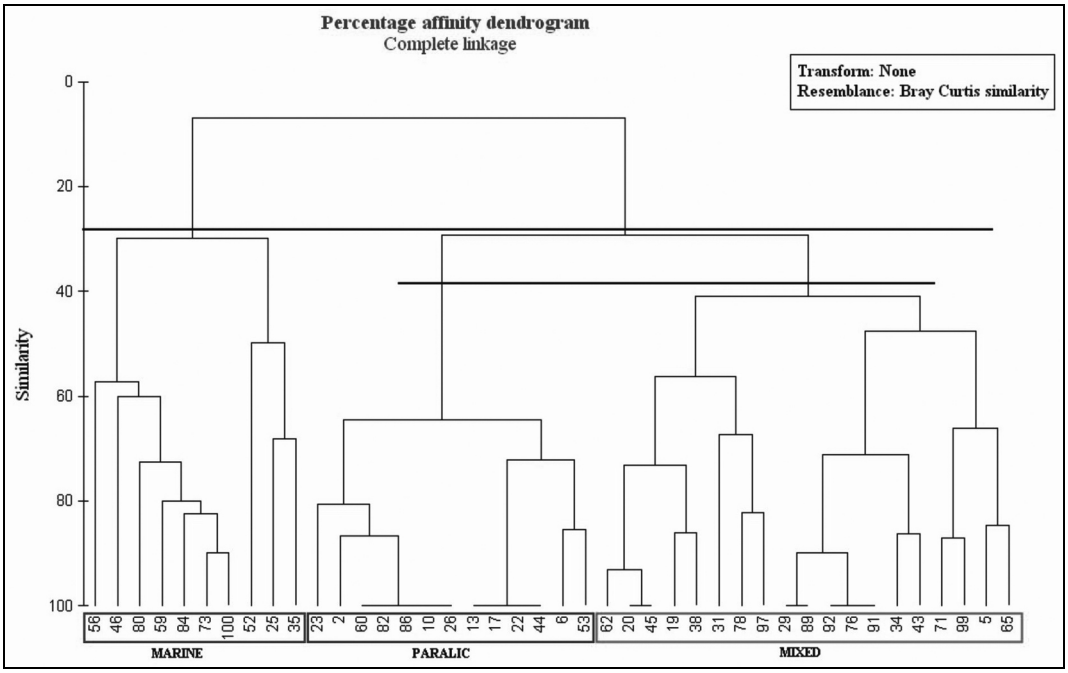


***Fig. 5: Dendrogram obtained by percentage affinity values.***
***Sl. 5: Dendrogram, narejen na podlagi afinitetnih vrednosti (v %).***

marine elements in relation to the extension of paralic domain. However, this definition should be considered on a larger scale since it is dependent on many other parameters such as tidal range, width inlets, freshwaters inputs, wind regime, depth, trophic conditions, transparency, oxygen content and so on.

Multivariate analysis in 2008 defined three different areas as a function of closeness to inlets and freshwaters inputs. The group of stations close to inlets could be defined as a lagoon community having marine characteristics; stations nearby the inner bank as a strictly paralic community; finally stations showing a combination of marine and paralic properties as a mixed community. This kind of partition was confirmed and validated by ANOSIM analysis; moreover k-dominance curves focused a basic community structure in each group. In the same way SIMPER analysis punctually identified the mostly involved species of the mentioned groups.

Three characteristic species of paralic environments and LEE biocenosis represent at least 60% of relative abundance in the Paralic group and dominate in inner zones where marine species cannot survive: *Abra segmentum*, *Hediste diversicolor* and *Streblospio shrubsolii*. *A. segmentum* is typically euryhaline, frequent in oligo-hyperhaline waters, tolerates a wide range of salinities, from 3 to 41 psu (Marazanof, 1969; Kevrekidis, 2004). It is common and frequently abundant in the Mediterranean coastal lagoons, where it plays a dominant role, both in terms of number and biomass, in the infauna of these habitats and represents an important food for fish (Kevrekidis & Kasapis, 2009). *H. diversicolor* preferentially lives in muddy sediments. It is a typical inhabitant of European brackish water habitats and shows a high level of tolerance towards different types and concentrations of contaminants (Volpi *et al.*, 1999). *H. diversicolor* tolerates a wide salinity range, preferring, in any case, areas characterized by low salinity values (Guerzoni & Tagliapietra, 2006) and it is largely distributed in Mediterranean lagoons (Bazaïri *et al.*, 2003; Nicolaidou *et al.*, 2005). *S. shrubsolii* is a typical lagoon species widely distributed also in other Mediterranean lagoons (Mistri *et al.*, 2002b; Rossi & Lardicci, 2002; Bazaïri *et al.*, 2003; Dauer *et al.*, 2003). Furthermore, Mixed and Marine groups were characterized by the dominance of polychaetes belonging to Capitellidae and Spionidae families represented by small size species capable to settle in habitats having a strong variability, such as transitional environments (Holte & Oug, 1996; Mistri *et al.*, 2002b) and adapted to colonize habitats with organic enrichment (Mistri *et al.*, 2001; Thouzeau *et al.*, 2007). Oligochaets, indicating desalinized water (Nicolaidou *et al.*, 2005), were abundant, too. In addition, the owenid *Myriochele oculata*, a sandy species especially diffused nearby inlets, contributed to define the Marine group.

The bionomic analysis (Pérès & Picard, 1964) revealed the existence of seven biocenoses. The main were LEE and SFBC, this latter is typical of marine domain and largely diffused in Mediterranean Sea as a soft bottom infralittoral biocenosis. The second dendrogram obtained by A% values was comparable to abundance

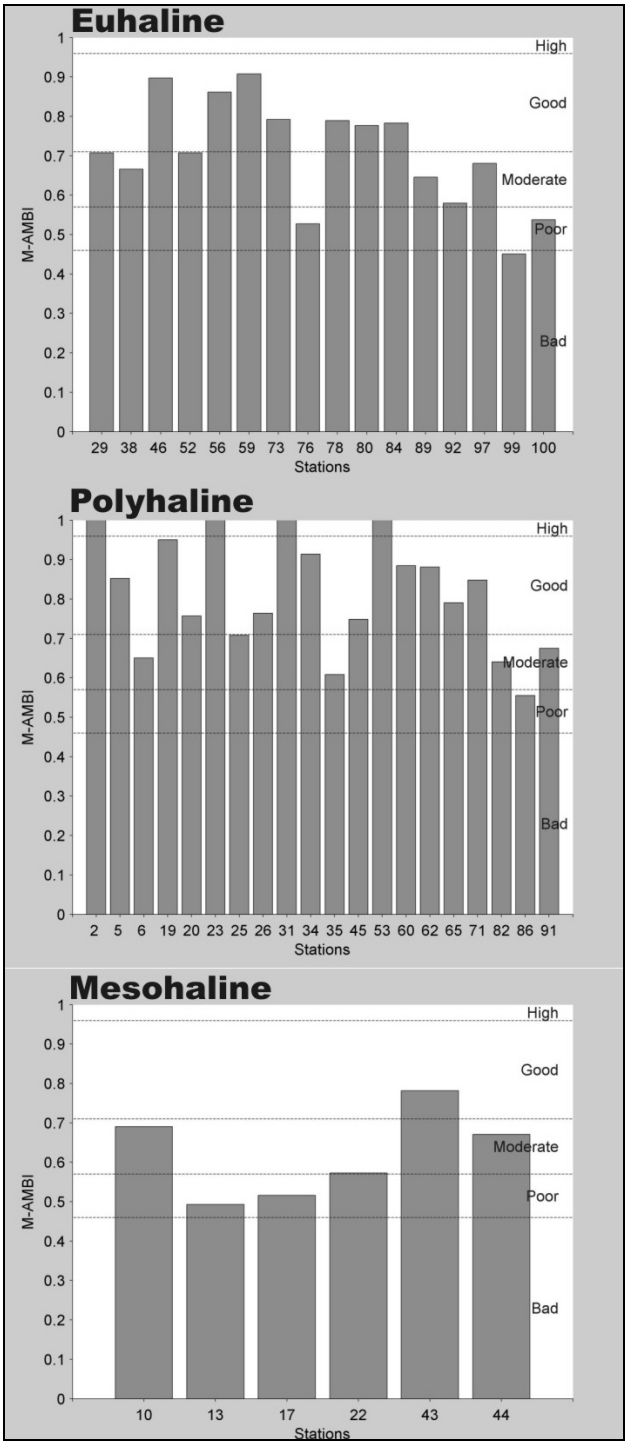


***Fig. 6: EcoQS of euhaline, polyhaline and mesohaline stations according to M-AMBI index.***
***Sl. 6: Ekološko stanje kakovosti (EcoQS) za evhaline, polihaline in mezohaline postaje na podlagi izračuna indeksa M-AMBI.***

cluster as revealed by RELATE procedure. In this way stations having Marine affinities are mostly represented by SFBC, whereas LEE is meanly <30%. LEE affinity in Paralic stations exceeds 65%, and LEE affinity in Mixed group ranges between 30 and 65%.

The Marine, Mixed and Paralic groups could correspond to zones II, III and IV-V respectively, as defined by Guelorgèt & Perthuisot's benthic zonation (Guelorgèt & Perthuisot, 1982, 1983, 1992). In fact, Marine group resembles the zone II, as a corresponding entrance into lagoon domain with the presence of most tolerant marine species belonging to SFBC and Fine Superficial Sands (SFS) biocenosis. Mixed group was similar to zone III with a remarkable scarcity or even disappearance of echinoderms. Vatova (1964a, 1965) noticed that the holothurioid *Trachythyone elongata* is the only capable to withstand sudden salinity changes and, in fact, only 7 specimens of 4 echinoderms species were found in the polyhaline water types *(T. elongata, Asterina gibbosa, Amphiura chiajei* and *Amphipholis squamata).* Finally, Paralic group resembled zone IV, because of the total disappearance of most tolerant marine species, such as echinoderms, and an absolute dominance of strictly paralic species such as *A. segmentum, Cerastoderma glaucum* and *H. diversicolor.* In some limited areas Paralic group resembled also zone V because of the appearance of chironomids larvae.

No specimens of the characteristic lagoon bivalve *Scrobicularia plana* were found in 2008. This species already recorded in the Marano and Grado Lagoon by Vatova (1964a, 1964b, 1965) and considered as particularly sensitive to river floods, was scarcely present in the 70's because of pollution phenomena (Battaglia *et al.*, 1972) and now it results to be absent since the 90's (Zamboni, 2008).

Macrozoobenthos in 2008 embraced a distribution comparable to the three years study 1993-1995 (Orel *et al.*, 2001; Zamboni, 2008). In the lagoon the salinity constitutes a sort of barrier to strictly marine species, leading to the selection of more tolerant organisms. In the inner part of the lagoon there is a clear dominance of LEE species accompanied by strongly opportunistic annelids.

The final goal was the application of indices proposed by WFD, in order to define the ecological quality status in each sampling station. M-AMBI showed a significant Good-Moderate quality status in euhaline stations. However, some sites located within heavily modified water bodies showed a Poor or Bad status. In polyhaline type 70% of stations showed Good to High EcoQS. Mesohaline type, the inner part of the Marano Lagoon, showed almost a Moderate status, due to natural selectivity of paralic habitats, characterized by low biodiversity. As suggested by Dauvin *et al.* (2009), the main issue in the application of indexes for the classification is that in order to determine anthropogenic stress,

they account to relative abundances of stress-tolerant species. However, these latter may also be tolerant to natural stressors. Moreover, due to the high variability of both physical and chemical parameters, transitional environments are generally characterized by low benthic diversity if compared to the marine environment with several opportunistic and tolerant organisms, withstanding these conditions. AMBI provides ecological group assignments based on expert opinion for a lot of taxa. Moreover the ecological behaviour of several species is quite different when they have to adapt to lagoonal conditions (Cognetti & Maltagliati, 2008) or to different geographical areas. The reference conditions for the final EcoQS are established by the legislation. Actually, in Italy, a draft document proposed by Italian Environmental Ministry provides the same reference condition for oligo-, meso- and polyhaline waters. As aforementioned the Marano and Grado Lagoon shows a quite different benthic community in the mesohaline waters compared to polyhaline waters. Hence the application of a single reference condition for these different types causes to classify mesohaline waters with Moderate or Poor quality. In this situation, in order to achieve at least the Good EcoQS in the whole Marano and Grado Lagoon, macrozoobenthic community should reach a number of species comparable to a typical soft bottom community of marine environments, thus loosing the characteristics and ecological functions of paralic environments.

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# OCENA EKOLOŠKEGA STATUSA ZDRUŽB VODNIH NEVRETENČARJEV V MARANSKI IN GRADEŠKI LAGUNI (SEVERNI JADRAN)

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*POVZETEK*

*Ocenjenjen je bil status združb vodnih nevretenčarjev v Maranski in Gradeški laguni, v skladu z aplikacijo Okvirne direktive o vodah za somornice. Vzorčenja bentosa so bila izvedena leta 2008. Na 42 vzorčevalnih postajah je bilo identificiranih 14.522 organizmov, pripadajočih 163 taksonom. Število taksonov in indeksi pestrosti so se zmanševali od mesta dotokov proti notranjemu bregu lagune, in sicer kot funkcija gradienta slanosti treh tipov vode. Multivariatna analiza in analiza bentoških biocenoz sta razkrili obstoj treh združb vodnih nevretenčarjev, vezanih na bližino/oddaljenost od morja. Dominantne vrste so tipični prebivalci lagunskega okolja, spremljajo pa jih oportunistične vrste, ki lahko tolerirajo velike variacije kemičnih in fizikalnih parametrov v somornicah. Indeks M-AMBI opredeljuje ekološko stanje glede na biotsko raznolikost.*

**Ključne besede:** vodni nevretenčarji, Maranska in Gradeška laguna, ekološki status, Okvirna direktiva o vodah, severni Jadran

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## 3rd International Expert Meeting on Marine Biodiversity in the Adriatic "Towards a representative network of Marine Protected Areas in the Adriatic", Piran, October 28th–29th, 2010

ZAVOD REPUBLIKE SLOVENIJE ZA VARSTVO NARAVE

The Adriatic Sea is a very special part of the Mediterranean region, with distinctive geographic, geomorphological, oceanographic and ecological characteristics. At the same time, the Adriatic marine environment is particularly vulnerable due to intense human pressure, such as coastal degradation, land-based pollution sources, fisheries, and tourism, over its limited water volume.

In 2006 and 2008, the Institute of the Republic of Slovenia for Nature Conservation organized two workshops on the conservation and threats to marine biodiversity in the Adriatic. The first was held on the occasion of the release of a book on endangered marine species and habitat types in the Slovenian sea, while the second workshop was dedicated to human impacts on marine biodiversity.

UNEP

MAP

RAC/SPA

Taking into account the "Regional Working Programme for the Coastal and Marine Protected Areas in the Mediterranean Including the High Seas", adopted within the framework of the Barcelona Convention, as well as the 2012 target adopted within the Convention on Biological diversity and the environmental policy of the European Union, in October 2010 the Institute decided to organize the third workshop on marine biodiversity conservation in the Adriatic. The organization of the workshop was financially supported by the Principality of Monaco and partly by the Regional Activity Centre for Specially Protected Areas of the Barcelona Convention, which accepted the role of a co-organizer. The direct objective of the meeting was to contribute to the implementation of the above mentioned programme and consequently, the central topic of the meeting were scientific basis, as well as procedural issues, ways and means to make a step forward towards a representative network of marine protected areas in the Adriatic. More than fifty experts from the countries around the Adriatic and from the wider Mediterranean area participated in the two-day workshop, 19 papers were presented and a number of posters, dealing with single protected areas were exhibited.

Two topics were addressed, namely the methodology and identification of priority conservation areas in the Adriatic and the identification of sites for the development of a representative network of MPAs in the Northern Adriatic. The introductory papers were presented by Chedly Rais (Okianos), Giuseppe Notarbartolo di Sciara (CIESM, ACCOBAMS Scientific Committee), Evangelos Papathanassiou (Research Director, Hellenic Centre for Marine Research, SESAME project), Tullio Scovazzi (International Law, University of Milano-Bicocca) and Joachim Claudet (National Center for Scientific Research, University of Perpignan). The program of the workshop and the two working documents are available on: http: //www.zrsvn.si/dokumenti/73/2/2010/Program_2 089.pdf

At the end of the workshop, the participants agreed on the following set of conclusions and recommendations:

1. The current situation of MPAs in the Adriatic (Mediterranean) is unsatisfactory in terms of representativity and in terms of management.
2. The MPA agenda is progressing too slowly to be able to accomplish the goal of protecting the region's biodiversity in order to halt and reverse degradation effectively.
3. An evaluation on the national level of the status, the representativity and the effectiveness of the marine and coastal protected areas should be carried out throughout the Adriatic countries as soon as possible. National strategies that aim to ensure conservation for all types of marine biodiversity, including resources, should be elaborated, ensuring also that appropriate human and financial resources are made

***The opening session of the Workshop. (Photo A. Popić)***

available to protected areas so that they can meet their goals.

4. An *ad hoc* multi-disciplinary working group of experts should be set up to:
   - take stock of existing habitat inventorying and/or mapping initiatives in the area,
   - initiate studies on connectivity throughout the Adriatic (habitat mapping, tagging, genetics etc.) and agree on a common assessment methodology and on a monitoring plan that could be conducted on a regular basis,
   - use a precautionary approach when data limitation cannot be overcome in an appropriate time frame;
   - identify missing scientific information concerning EBSAs and propose ways and means to secure this missing information, and
   - on the basis of the EBSA defined in the Adriatic, and the findings of the relevant recent investigations, further develop the identification of marine areas that could be proposed as SPAMIs.
5. The relevant organizations such as RAC/SPA, IUCN, WWF, etc. are invited to provide support and facilitate the setting up of this working group as well as the progress of the work.
6. The administrative and legal constraints to the establishment of SPAMIs in areas beyond the territorial waters, including deep waters should be identified.
7. Based on the national strategies and regularly updated with the newly achieved scientific information, a sub regional (Adriatic) strategy with the aim to ensure conservation for all types of marine habitats in the Adriatic should be elaborated and implemented through the existing or newly developed frameworks.
8. In addition to the development of a representative network of MPAs, it is of the uttermost importance in terms of conservation that the national strategies, as well as the regional ones, focus also on a better governance system outside MPAs. In this context, The EU Integrated Maritime Policy, in particular Marine Spatial Planning (MSP) has the potential to help further integration of the MPAs with the other seas uses. Identification, design and effective management of MPAs should be included as a priority in the process of Marine Spatial Planning.

The above conclusions and recommendations were for further consideration sent to the UNEP MAP Coordinating Unit in Athens and to the Regional Activity Centre for Specially Protected Areas, to the Mediterranean Action Plan and Secially Protected Areas National Focal Points, to the Commission for the protection of the Adriatic and its Coastal Zone and to the European Commission's Environment Directorate-General.

**Robert Turk**

## IN MEMORIAM PROF. TONE WRABER

Ko sem pred dobrima dvema letoma pisal besedilo ob sedemdesetletnici profesorja Toneta Wraberja, nisem niti slutil, da bo prišel čas za nekrolog tako neusmiljeno zgodaj in iznenada. Profesor je odšel po krajši, a hudi bolezni 6. julija 2010.

Profesor Wraber se je rodil 4. marca 1938 v Ljubljani v intelektualno bogatem okolju. Njegov oče je bil znani slovenski fitocenolog dr. Maks Wraber, kar je prav gotovo vplivalo na njegovo nadaljnjo pot, saj se je pokojni Tone "okužil" z ljubeznijo do rastlinskega sveta že zelo zgodaj. Enoumje takratne politike je utesnjevalo svobodnejši duh in drugačne nazore Tonetove družine. Kot otrok je doživel hude stiske, saj je bil oče nekaj časa celo politični zapornik; to je morda še podžgalo Tonetovo željo in slo k čim širši in čimbolj poglobljeni izobrazbi in razgledanosti, ki smo jo mlajši kolegi pri njem tako občudovali.

Po maturi na klasični gimnaziji v Ljubljani leta 1956 je v letih 1956–61 študiral biologijo na Univerzi v Ljubljani. Po diplomi se je najprej zaposlil kot kustos v Prirodoslovnem muzeju Slovenije, že leta 1963 pa je izšel njegov vodnik "Naše zaščitene rastline", prvo pomembnejše delo botaničnega naravovarstva do tedaj. Leta 1968 je bil imenovan za asistenta v Botaničnem vrtu Ljubljanske univerze. To je bilo obdobje številnih terenskih ekskurzij po Sloveniji, katerih rezultat so bile nove najdbe za floro Slovenije in številna nova nahajališča redkih vrst. Predvsem pa vestno in prizadevno zbiranje herbarijskega materiala za zbirko Herbarija Univerze v Ljubljani. Čas bo pokazal kratkovidnost današnjega vrednotenja znanosti, utesnjenega v številke in točkovanja, ki pa ne zmore oceniti časa, znanja in energije potrebne za to, da sistematično obdeluješ floro ozemlja, kjer uspeva 3000 rastlinskih vrst! In greš seveda tudi prek meja, v bližnje in oddaljene države! Leta 1973 je Tone Wraber začel univerzitetno kariero kot asistent, upokojil se je kot redni profesor pred dobrima dvema letoma, maja 2010 pa je bil imenovan tudi za zaslužnega profesorja Biotehniške fakultete.

Profesorju Wraberju je bogato poznavanje jezikov in stroke omogočalo daljša študijska bivanja v tujini. Komaj triindvajsetleten mladenič se je že izpopolnjeval v fitocenologiji pri začetniku srednjeevropske fitocenološke šole, profesorju Braun-Blanquetu v Montpellierju v Franciji. Daljši čas je deloval na univerzi v Trstu pri vodilnem italijanskem botaniku Sandru Pignattiju, pod mentorstvom katerega je leta 1972 izdelal tudi doktorsko disertacijo o vegetaciji skalnih razpok v Julijskih Alpah.

Plodovita so bila tudi njegova študijska bivanja v Londonu, kjer je obdeloval botanično gradivo, pridobljeno na njegovih eksotičnih ekskurzijah. Z njimi je začel že leta 1969 kot udeleženec jugoslovanske odprave na Anapurno in 1972 na Makalu. Med čezmorskimi ekskurzijami je bila še posebno uspešna tista v Centralnoafriško republiko. Profesorju ni bila tuja niti eksotika naše nekdanje skupne države. Veliko energije in časa je namreč posvetil raziskovanju flore Balkana, predvsem Kosova, Makedonije, Albanije in Črne Gore.

S ponosom lahko zapišem, da je profesor Wraber postal moj mentor že v gimnazijskih letih. Obiskal je koprsko gimnazijo in imel tam predavanje, naslednjega dne pa smo šli na terensko ekskurzijo; ker je deževalo, jaz pa nisem imel dežnika, sem vedril pod njegovim … In čez eno leto je bil že moj mentor pri raziskovalni nalogi. Zame nepozabna je bila študentska ekskurzija na Kosovo leta 1984. Njegovo odlično poznavanje tamkajšnjih razmer, tako družbenih kot naravnih, je nam, študentom, omogočilo vpogled v eksotiko rastlinstva in navad Balkana. Profesor Wraber nam je odkrival botanično najslabše poznane in najbolj zakotne predele takratne Jugoslavije; vselej pa je bil tudi vir podatkov o zgodovini, etnologiji in kulturi območja, skozi katerega smo potovali.

Če so bile ena od Wraberjevih ljubezni Alpe, je bila druga prav gotovo Mediteran. Po mami je bil Primorec in odličen poznavalec družbenih razmer v Istri in na Tržaškem. V sedemdesetih in osemdesetih letih je botanično "ponovno odkril" Slovensko Istro: Osp, Strunjan in Ronek, Steno in Sv. Štefan v dolini Dragonje, Sečoveljske soline, Sv. Katarino pri Ankaranu, Kubed ... Tudi njegova zasluga je, da so ti enkratni prostorčki danes zakonsko zavarovana območja.

Profesor Wraber je opisal sedem za znanost novih taksonov, drugim je revidiral taksonomski status, našel je desetine novih vrst za floro Slovenije in nova nahajališča redkih vrst. Pri tem pa ne smemo pozabiti na Toneta Wraberja kot izkušenega fitocenologa klasične šole, ki se ukvarja predvsem z združbami nad gozdno mejo, s skalnimi razpokami in melišči.

Meni bo ostal pokojni Tone najbolj v spominu kot pedagog, saj sem bil njegov prvi (torej najstarejši) doktorand. Njegova predavanja so bila vselej odlično pripravljena, podkrepljena z diapozitivi z vseh koncev sveta in obogatena z zanimivostmi.

V svoji karieri je bil urednik ali član uredniškega odbora Proteusa, Scopolije, Varstva narave, Hladnikije, tudi koprskih Annalov. Bil je tudi ustanovitelj in predsednik Botaničnega društva Slovenije, aktiven član številnih mednarodnih združenj, njegova bogata bibliografija – če se omejimo le na strokovno in znanstveno – pa posega v področja floristike, taksonomije, botanične zgodovine, fitocenologije in varstva narave.

Ko se je profesor Wraber po upokojitvi umaknil z univerze in se preselil na deželo, v Polhov Gradec, se je posvetil rastlinam tudi na svojem vrtu, lotil se je nedokončanih projektov, neutrudno je pisal, praktično dokler mu je težka bolezen to dopuščala. Po njegovem odhodu je zazijala v slovenski botaniki nepopisna praznina, saj ni nikogar, ki bi ga lahko nadomestil v njegovem znanju

in širini. Odšel je zadnji klasični botanik v Sloveniji, ki je vedel "vse" o rastlinah; rodoljub, poliglot, naravovarstvenik, gornik ... Naj mu bo lahka domača zemlja, ki jo je tako dobro poznal in tako močno ljubil!

## IN MEMORIAM PROF. TONE WRABER

Two years ago, when I was writing a text for the occasion of Prof. Tone Wraber's 70th birthday, I could hardly imagine that the need for an obituary would come so very early and suddenly. The professor passed away after a brief but serious illness on 6 June 2010.

Professor Wraber was born on 4 March 1938 in Ljubljana in an intellectually rich environment. The fact that his father was a known Slovene phytocenologist Dr. Maks Wraber surely influenced his career path, evoking late Tone's love for plants at a very early age. Political narrow-mindedness in those days stifled the free spirit and liberal beliefs of Tone's family. His father was even a political prisoner, which caused Tone great distress as a child; it might have also encouraged his need and passion for a broad and complex education and worldliness that younger colleagues so admired in him.

After finishing the classical gymnasium in Ljubljana in 1956, he studied Biology at the University of Ljubljana from 1956 to 1961. Upon his graduation, he started working as the curator of the Slovenian Museum of Natural History. In 1963 he published his guidebook "Naše zaščitene rastline", the first relevant work on botanical conservation. Five years later he was appointed assistant at the Botanic gardens of the University of Ljubljana. That was the period of numerous field excursions around Slovenia, which resulted in new findings of Slovenian flora and several new localities of rare species, but most of all it was the time of conscientious and intense work on the herbarium collection for the Herbarium of the University of Ljubljana. Time will judge the improvidence of the current system for evaluation of science, limited to numbers and points yet unable to evaluate the time, knowledge and energy needed for the systematical study of flora in the area with 3000 plant species! With travels to nearby and distant countries! In 1973, Tone Wraber started his university career as an assistant, and retired as a full professor two years ago. In May 2010, he was named distinguished professor of the Biotechnical Faculty.

Due to his extensive knowledge of languages and his professional field, Professor Wraber was able to study abroad for a long period of time. As a 23-year-old student he worked with the founder of the Central European Phytocenological School, professor Braun-Blanquet in Montpellier in France, building on his knowledge of phytocenology. For an extended period of time he worked at the University of Trieste with the leading Italian botanist Sandro Pignatti, who also mentored his doctoral dissertation on rock-crevice vegetation in the Julian Alps in 1972.

His study stays in London were also very productive, with extensive work done on the botanical material from his exotic excursions. His first was in 1969 when he joined the Yugoslav expedition to Annapurna and in 1972 to Makalu. Among overseas excursions, the one to the Central African Republic was particularly successful. Even the exoticness of our former common country was not foreign to the professor – he dedicated a lot of his energy and time to the research of the Balkan flora, mostly in Kosovo, Macedonia, Albania and Montenegro.

I can proudly say that Professor Wraber became my mentor when I was still in secondary school. At one occasion, he visited the gymnasium in Koper, gave a lecture there and the following day took us on a field excursion. It was raining; I didn't have an umbrella, so he kindly offered me shelter under his. One year later, he was already my mentor for a research paper. For me, an unforgettable experience was the study excursion to Kosovo in 1984. His extensive knowledge of local conditions, both social and natural, gave us, the students, an insight into the exotic vegetation and also habits and customs of the Balkans. Professor Wraber showed us the botanically least known and the remotest parts of former Yugoslavia; and always provided additional information on history, ethnology and culture of the area that we were travelling through.

If one of Professor's loves were the Alps, the other one was surely the Mediterranean. His mother was from Primorska, and he was well acquainted with the cultural situation in Istria and Trieste with its surroundings. In the 70s and 80s he botanically "re-discovered" Slovenian Istria: Osp, Strunjan and Ronek, Stena and Sv. Štefan in the Dragonja Valley, the Sečovlje salt pans, Sv. Katarina near Ankaran, Kubed ... Also to his credit, these unique spots are nowadays legally protected areas.

Professor Wraber described seven taxa previously unknown to science; he revised taxonomic status of others, found tens of new species for the Slovene flora and new localities of rare species. In addition to all of this, we must not forget Tone Wraber as an experienced phytocenologist of the classical school, which deals mostly with plant communities above the timberline, rock-crevices and taluses.

The late Tone will stay in my memory mostly as a teacher, since I was his first (and therefore the oldest) doctoral student. His lectures were always immaculately prepared, supported by slides taken from all around the world and rich in interesting facts.

In the course of his career, he was an editor and a member of the editorial board of Proteus, Scopolija, Varstvo narave, Hladnikija, and Annales from Koper. He was the founder and president of the Botanical Society of Slovenia, active member of numerous international associations, his vast bibliography – if we limit ourselves only to scientific and research texts – covers the fields of floristry, taxonomy, history of botany, phytocenology and nature conservation.

When Professor Wraber retired and left the university to live in the countryside in Polhov Gradec, he dedicated himself to plants in his garden, he worked on his unfinished projects, he wrote untiringly as long as the serious disease allowed him. His death left an immense void in Slovenian botany, since there is no one left who could match him in his knowledge and broad mind. The last classical Slovenian botanist, who knew "everything" about plants, left; a patriot, polyglot, conservationist, mountaineer ... May he rest in peace in the home soil that he knew so well and loved so much!

**Mitja Kaligarič**

## ŽIGI DOBRAJCU V SLOVO (1979–2010)

Konec julija 2010 nas je razžalostila novica o tragični nesreči našega sodelavca in prijatelja Žige, ki se je udeležil predstavitve potapljanja z uporabo rebreatherjev v Miramaru pri Trstu.

Žige se spominjamo kot tople, odprte osebe, ki je znala hitro navezati stik v družbi. Bil je navdušen košarkar in potapljač. Njegova ljubezen do morja je bila tako močna, da je vpisal študij biologije na ljubljanski

univerzi z željo, da bi se dokopal do poklica, ki bi ga povezal z morjem, mu omogočil raziskovati njegove skrivnosti. In tako se mu je tistega dne, ko ga je njegov prijatelj Borut pripeljal na Morsko biološko postajo, da se dogovori za opravljanje diplomske naloge, začela nasmihati možnost, da uresniči svoje sanje. Idejo, da bi raziskoval favno kriptobentoških rib, je sprejel z odprtimi rokami, saj ga je veselila tako z vidika skrivnostnih rib kot tudi zaradi potapljanja, brez katerega pri nalogi ne bi šlo. Dela se je lotil zelo predano in zavzeto in res, rezultati niso izostali. Skupaj s sodelavci je objavil nekaj znanstvenih prispevkov, tudi v naravoslovnih Analih. Uspelo mu je odkriti nenavadne ribice, o katerih je komajda kaj znanega. Še preden je zaključil z vzorčenjem za diplomsko nalogo, je bil zaradi svojih vrlin sprejet v delovno razmerje na Morski biološki postaji Nacionalnega Inštituta za Biologijo, kjer je osnovne biološke veščine nadgradil s praktičnim delom na raziskovalnih plovilih in v laboratoriju ter na vzorčenjih pod vodo.

Z Žigo so prišle na postajo tudi nekatere povsem nove danosti. V avli postaje je vzpostavil sistem velikih akvarijev, v katere je naselil samoniklo ribjo združbo in mnoge pridnene nevretenčarje. Veliko večino življa je polovil sam, nekatere tudi v številnih nočnih potopih. Seveda so lično urejeni akvariji in pestro življenje v njem, za katerega je zgledno skrbel, postali obvezna točka za obiskovalce iz osnovnih in srednjih šol pri ogledu biološke postaje. Pred kratkim je postal tudi ladjevodja raziskovalnega plovila. Udeležil se je mnogih mednarodnih delavnic na temo podvodnih vzorčenj in raziskovalnih veščin v različnih sredozemskih krajih. Še posebej rad je sodeloval z avstrijskimi kolegi iz raziskovalne skupine dr. Michaela Stachowitscha in jim pomagal pri vzorčenjih v slovenskem morju. Žal ni imel priložnosti, da bi nam uspel pokazati celoten obseg svojega raziskovalnega potenciala.

V zadnjih letih je opravil ogromno število podvodnih vzorčenj, se seznanil z različnimi tehnikami zajemanja vzorcev in postal dober podvodni fotograf. Delo pod vodo ga je najbolj veselilo. Koliko mu je pomenilo, dobro pove odgovor, ki ga je dal v nekem intervjuju: *"Če sem živčen, če kaj ne štima, grem pod vodo, kjer je mir, tišina, morski zvok. Super je, da se malo odklopiš, nazaj prideš kot nov."*

Podvodni snemalec je postal povsem po naključju. Ko je v slovensko morje februarja 2009 zašel trinajstmetrski kit grbavec, si je Žiga brez oklevanja nadel potapljaško obleko in skočil v vodo. Marsikdo bi pred takšnim dejanjem dvakrat premislil, toda ne Žiga. On je živel v skladu s svojo percepcijo življenja, živel je za trenutke. Kot navdušen filmofil bi gotovo citiral Willa Smitha v filmu Hitch: *"Življenje ni število vdihov, ki jih narediš, temveč število trenutkov, ki ti vzamejo sapo"*. In tisti trenutek je vzel sapo ne samo Žigi, ampak tudi drugim, ki smo lahko prisostvovali druženju z grbavcem. Eden zadnjih takih trenutkov je bil še pred nekaj tedni, ko smo se po opravljenem vzorčenju podružili s trojico delfinov blizu oceanografske boje.

Odiseja strastnega zaljubljenca v morje se je tragično zaključila v Miramaru, kamor ga je prignala želja po izpopolnjevanju v potapljaških veščinah. Danes akvariji samevajo, terenska vzorčenja so turobna in tiha … V naših srcih ostajajo lepi spomini na vedrega in marljivega sodelavca in prijatelja!

V imenu sodelavcev Morske biološke postaje NIB
**Lovrenc Lipej**

## IN THE MEMORY OF ŽIGA DOBRAJC (1979–2010)

At the end of July 2010, we learned the sad news about the tragic accident of our colleague and friend Žiga, who attended the presentation of rebreather diving at Miramar near Trieste.

We will remember Žiga as a warm, open and sociable person. He was an enthusiastic basketball player and diver. His love for the sea was so strong that he enrolled at the Faculty of Biology at the University of Ljubljana in the hope of a profession which would connect him to the sea and enable him to search through its secrets. And so one day his friend Borut brought him to the Marine Biology Station to arrange his diploma thesis and Žiga came closer to fulfilling his dream. He grabbed the opportunity to do a research on the cryptobenthic fish fauna with both hands, not only because of the mysterious fish but also the diving, which was required. He was enthusiastic and devoted to his work, and soon the results were there to prove it. In cooperation with his colleagues, he published a few articles, also in Annales Series Historia Naturalis. He managed to discover unusual and hardly known fish. Before finishing his sampling for the thesis, the Marine Biology Station of the National Institute of Biology employed him due to his excellent qualities. He upgraded his core biological skills with field work on research vessels and in laboratory and with underwater sampling.

Žiga added many novelties to the Marine Biology Station; in the station lobby he set up a system of large tanks, and filled them with an indigenous fish assemblage and numerous benthic invertebrates. He caught most of the animals himself, some also while night diving. Needless to say that the tanks and the vivid life in them, which he meticulously cared for, drew attention of the elementary and secondary school visitors to the marine station. Not long ago, Žiga was appointed the head of the research vessel. He attended numerous

international workshops on underwater sampling and research skills in various Mediterranean towns. He especially liked working with our Austrian colleagues from Dr. Michael Stachowitsch's research team, helping them with sampling in the Slovenian sea. Unfortunately, he never had a chance to show us the full spectre of his research potential.

In the course of the last few years, he did a large number of underwater samplings, got acquainted with various sampling techniques and became an excellent underwater photographer. Work under water was the thing he enjoyed most. How much it meant to him is illustrated in the following answer from one of the interviews: *"If I'm nervous, if there's something wrong, I go under water where there is peace and quiet and the sound of the sea. It's great to relax, you come back a new man."*

He started working as an underwater photographer purely by chance. When in February 2009, a 13-meter-long humpback whale found itself in the Slovenian sea, Žiga put on his diving suit without hesitation and jumped into the sea. A lot of other people would think twice before doing something like that, but not Žiga. He lived according to his own rules, he lived for the moments. As an enthusiastic film buff he would surely quote Will Smith in Hitch: *"Life is not measured by the breaths you take, but by the moments that take your breath away."* And that moment didn't take only Žiga's breath away; all of us who came close to the whale were speechless. One of these moments, the last one, happened only a few weeks ago when we were socializing with three dolphins after finishing sampling near an oceanographic buoy.

The journey of a passionate sea lover ended tragically at Miramare, in his pursuit to improve his diving skills. Today the aquarium tanks are empty; field samplings are gloomy and quiet... In our hearts we keep the memories of a joyful and diligent colleague and friend!

On behalf of all the Marine Biology Station NIB staff
**Lovrenc Lipej**